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VOL. VII, 1874.

Part 1 (out of print).—Annual report for 1873. Hill ranges between Indus valley in Ladak and Shah-i-Dula on frontier of Yarkand territory. Iron ores of Kumaon. Raw materials for iron-smelting in Raniganj field. Elastic sandstone, or so-called Itacolumyte. Geological notes on part of Northern Hazaribagh.
Part 2 (out of print).—Geological notes on route traversed by Yarkand Embassy from Shah-i-Dula to Yarkand and Kashgar. Jade in Karakas valley, Turkistan. Notes from Eastern Himalaya. Petroleum in Assam. Coal in Garo Hills. Copper in Narbada valley. Potash-salt from East India. Geology of neighbourhood of Mari hill station in Punjab.
Part 3.—Geological observations made on a visit to Chaderkul, Thian Shan range. Former extension of glaciers within Kangra district. Building and ornamental stones of India. Materials for iron manufacture in Raniganj coal-field. Manganese-ore in Wardha coal-field.
Part 4 (out of print).—Auriferous rocks of Dhambal hills, Dharwar district. Antiquity of human race in India. Coal recently discovered in the country of Luni Pathans, south-east corner of Afghanistan. Progress of geological investigation in Godavari district, Madras Presidency. Subsidiary materials for artificial fuel.

VOL. VIII, 1875.

Part 1.—Annual report for 1874. The Altum-Artush considered from geological point of view. Evidences of 'ground-ice' in tropical India, during Talchir period. Trials of Raniganj fire-bricks.
Part 2 (out of print).—Gold-fields of south-east Wynaad, Madras Presidency. Geological notes on Khareean hills in Upper Punjab. Water-bearing strata of Surat district. Geology of Scindia's territories.
Part 3 (out of print).—Shahpur coal-field, with notice of coal explorations in Narbada region. Coal recently found near Moflong, Khasia Hills.
Part 4 (out of print).—Geology of Nepal. Raigarh and Hingir coal-fields.

VOL. IX, 1876.

Part 1 (out of print).—Annual report for 1875. Geology of Sind.
Part 2.—Retirement of Dr. Oldham. Age of some fossil floras in India. Cranium of Stegodon Ganesa, with notes on sub-genus and allied forms. Sub-Himolayan series in Jamu (Jammoo) Hills.
Part 3.—Fossil floras in India. Geological age of certain groups comprised in Gondwana series of India, and on evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. Relations of fossiliferous strata at Maleri and Kota, near Sironcha, C. P. Fossil mammalian faunæ of India and Burma.
Part 4.—Fossil floras in India. Osteology of Merycopotamus dissimilis. Addenda and Corrigenda to paper on tertiary mammalia. Plesiosaurus in India. Geology of Pir Panjal and neighbouring districts.

VOL. X, 1877.

Part 1.—Annual report for 1876. Geological notes on Great Indian Desert between Sind and Rajputana. Cretaceous genus Omphalia near Nameho lake, Tibet, about 75 miles north of Lhassa. Estheria in Gondwana formation. Vertebrata from Indian tertiary and secondary rocks. New Emydine from the upper tertiaries of Northern Punjab. Observations on under-ground temperature.

RECORDS OF

THE GEOLOGICAL SURVEY OF INDIA.

Part I.] 1909. [September

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1908. BY SIR T. H. HOLLAND, K.C.I.E., D.Sc., F.R.S., *Director*.

CONTENTS.

INTRODUCTION.

THIS summary of results obtained by the officers of the Department during 1908 is designedly brief regarding most of the subjects, as they have been dealt with in separate papers published in the *Records* and *Memoirs*. Where, however, the work done cannot be closed and described for some years, as in the case of the great stretch of previously unsurveyed land in Central India and Rajputana, fuller details are given.

2. The brief summary of progress in mineral development published with this Report will be superseded shortly by the Quinquennial Review for the period 1904-08 now nearly ready for publication. The total value of minerals for which trustworthy returns could be obtained in 1908 show again an advance on previous years, while the licenses and leases granted for prospecting and mining in Government lands greatly exceeded all previous records.

DISPOSITION LIST.

3. During the period under report the officers of the Department were employed as follows :—

Superintendents.

MR. T. H. D. LATOUCHE. Returned from leave on the 4th February 1908. At headquarters in charge of office and officiating Director up to the 13th October 1908. Proceeded to the field on the 14th October 1908 to examine certain irrigation weir sites in the United Provinces and Central India and to report on the gypsum deposits of Hamirpur, United Provinces, and the coal deposits in the Shahpur District, Punjab.

MR. C. S. MIDDLEMISS. At headquarters in charge of office up to the 4th February 1908. Placed in charge of the Central India party for extension of the geological map over previously unsurveyed areas in Central India and the neighbouring States of Rajputana and left for the field on the 21st February 1908. Returned to headquarters on the 26th April 1908. Deputed on the 23rd June 1908 to Kashmir to survey the plant-bearing beds underlying the Zewan stage of Kashmir. Returned from Kashmir on the 11th October 1908 and assumed charge of the office at headquarters.

MR. H. H. HAYDEN. Services at the disposal of the Foreign Department up to the 31st March 1908 Granted 3 months' privilege leave

and in continuation furlough for 5 months with effect from the 7th May 1908. On deputation in connection with the Mining Exhibition (1908) from July 7th to August 6th. Returned from leave on the 21st December 1908.

Assistant Superintendents.

MR. P. N. DATTA. — Returned from the Central Provinces on the 18th April 1908. Deputed on the 17th November 1908 to Thaton District, Burma, for the mapping of previously unsurveyed areas in Lower Burma, with special attention to the occurrences of rock probably suitable for use as road-metal.

MR. E. VREDENBURG. — At headquarters as Palæontologist.

MR. L. L. FERMOR. — Returned to headquarters from the field on the 18th April 1908. Granted 3 months' privilege leave with effect from the 3rd July 1908. Returned from leave on the 12th October 1908, and deputed on the 7th November 1908 to the Central Provinces and Berar Industrial Exhibition and to inspect the manganese mines in the Central Provinces.

MR. G. E. PILGRIM. — Returned from Baluchistan on the 10th April 1908. Deputed to survey the ossiferous deposits in Kohat. Salt Range and the Siwaliks and left for the field on the 29th September 1908.

MR. G. H. TIPPER. — Returned from leave on the 13th July 1908. Appointed Curator on the 1st November 1908.

MR. H. WALKER. At headquarters as Curator up to the 31st October 1908. Deputed to revise the geological map of the Raniganj coalfield in conjunction with a Committee appointed by the Mining and Geological Institute of India, and left for the field on the 9th November 1908.

MR. E. H. PASCOE. Returned from Burma on the 4th June 1908. Reposted to Burma in connection with the petroleum industry, including the examination of the volcano of Popa in the Myingyan District. Left for the field on the 30th August 1908.

MR. K. A. K. HALLOWES. Returned to headquarters from the Singbhum District, Bengal, on the 30th April 1908. Granted six weeks' privilege leave with effect from 12th October 1908. Returned from leave on the 23rd November 1908. Posted to Mr. Pascoe's party in Burma with special reference to the survey of the volcanic hills in the neighbourhood of the volcano of Popa in the Myingyan district, and left for the field on the 1st November 1908.

MR. G. DE P. COTTER. Returned from Burma on the 14th May 1908. Granted 3 months' privilege leave with effect from the 3rd July 1908. Returned from leave on the 12th October 1908 and reposted to Burma in connection with the petroleum industry. Left for the field on the 25th October 1908.

MR. J. COGGIN BROWN. Returned to headquarters on the 11th June 1908. Deputed to Yunnan for Natural History explorations,

and left for field on the 27th December 1908.

MR. J. J. A. PAGE. Returned to headquaters from Burma on the 7th June 1908. Reposted to South Burma to continue his investigations of the tin deposits and left headquarters on the 16th October 1908.

MR. H. C. JONES. Returned from the field on the 25th April 1908. Reposted to Central India for a continuation of the previous season's work, and left for the field on the 16th October 1908.

MR. A. M. HERON. Returned from the field on the 12th May 1908. Reposted to the Central India and Rajputana party, and left for the field on the 16th October 1908.

MR. M. STUART. Deputed to investigate the kaolin deposits and glass-making materials of the Rajmahal Hills, Bengal, and left for the field on the 18th January 1908. Returned to headquarters on the 19th May 1908. Posted to Mr. Pascoe's party in Burma and left for the field on the 30th October 1908.

MR. N. D. DARU. Deputed to report on the pyritous shales and alum manufacture near Kalabagh, Mianwali district, Punjab, and left for the field on the 28th January 1908. Returned from the field on the 23rd April 1908. Posted to the Central India and Rajputana party and left for the field on the 12th October 1908.

Chemist.

DR. W. A. K. CHRISTIE. Deputed to Pachbadra from the 15th April to 10th June 1908 in connec-

tion with the investigations regarding the origin of the Rajputana salt. At headquarters for the rest of the period under report.

Sub-Assistants.

S. SETHU RAMA RAU. — Returned to headquarters from the field on the 31st May 1908. Posted to Mr. Pascoe's party in Burma and left for the field on the 27th October 1908.

M. VINAYAK RAO. — Deputed on the 9th May 1908 to Pachbadra, Rajputana, in connection with the investigations regarding the origin of the Rajputana salt. Returned to headquarters on the 31st July 1908. Posted to Mr. Pilgrim's party and left for the field on the 1st October 1908.

Assistant Curator.

MR. T. R. BLYTH. — On duty at headquarters throughout the period under report.

STUDENTS IN TRAINING.

4. The following students were under training during the year:—

G. G. NARKE, M.A., holding a scholarship from the Central Provinces Administration, was under Mr. Fermor in Singbhum and the Central Provinces from January to April 1908, and was thus given experience of crystalline areas, with copper, chrome, iron and manganese-ore deposits. He was deputed with Mr. Walker to the Raniganj field in November to receive training on stratigraphical problems in the coalfields.

KIRAN KUMAR SEN-GUPTA, M.A., was appointed to a Research Scholarship by the Bengal Government, and, in addition to work in the Laboratory and Museum, was given field work under Mr. Fermor in Singbhum, with the special task later of studying the granophyric complex of the Akarsani hills.

S. R. GHATPANDE was appointed by the Indore Durbar in July 1908, and, after training at headquarters, was deputed for field work under Mr. H. C. Jones in Central India.

HIRA LAL MOTI LAL SHAH, L.C.E., deputed by the Baroda Durbar in July, was trained at headquarters and afterwards under Mr. LaTouche in the Hamirpur District.

BYAS SHANKAR LAL, B.A., appointed by the Marwar Durbar in August, was trained in the Laboratory, and afterwards under Mr. Heron on the Aravalli series in the Alwar State.

SHEOPRASAD GARGAVA, B.A., B.Sc., appointed by the Gwalior Durbar, and LALA JOTI PERSHAD, B.A., appointed by Kashmir, arrived towards the end of the year, and were thus kept at headquarters for training.

All, except one, of these students made satisfactory progress, and have been reported on accordingly.

Geological classes, Presidency College.

5. The senior students of the Presidency College, Calcutta, were also permitted to work in the Museum and Babu Hem Chandra Das Gupta, the Demonstrator in the Geological classes, was engaged in palæontological research work. The Professorship of Geology, established in 1892, is held by one of the officers of the Geological Survey (at present Mr. E. Vredenburg), and although it is desirable to continue this direct connection between the Department and the teaching of Geology, it is necessary to increase the staff of demonstrators in order that the students, now numbering over 60, may receive more individual attention in practical work.

ADMINISTRATIVE CHANGES.

6. Sir T. H. Holland's services were placed at the disposal of the Burma Government from 1st September to 19th November 1908.

Appointments.

Mr. T. H. D. LATOUCHE, Superintendent, was appointed to officiate as Director during the absence on deputation of Sir T. H. Holland with effect from the forenoon of the 1st September 1908.

Mr. G. H. Tipper was appointed Curator with effect from the 1st November 1908.

Promotion.

7. Mr. P. N. DATTA, Assistant Superintendent, was appointed to officiate as Superintendent, with effect from the 7th May 1908, *vice* Mr. H. H. Hayden on combined leave.

Confirmation.

8. The following officers were confirmed in their appointments as Officers of the Geological Survey Department:—

Mr. K. A. K. HALLOWES.
Mr. J. J. A. PAGE.
Mr. H. C. JONES.
Mr. A. M. HERON.

Leave.

9. Mr. H. H. HAYDEN was granted 3 months' privilege leave and in continuation furlough for 5 months, with effect from the 7th May 1908.

Mr. L. L. FERMOR was granted 3 months' privilege leave with effect from the 3rd July 1908.

Mr. G. de P. COTTER was granted 3 months' privilege leave with effect from the 3rd July 1908.

Mr. K. A. K. HALLOWES was granted six weeks' privilege leave with effect from 12th October 1908

OBITUARY.

A. Tween.

10. I have to report, with regret, the death of two past members of the Department, Mr. A. Tween and Mr. W. Theobald. Mr. Tween was appointed an Assistant in 1859, and became the first Curator of the Museum and Laboratory; but he was compelled to retire owing to ill-health in 1876. Although only one paper was published by Mr. Tween, his work as Chemist largely contributed to the value of memoirs published by his colleagues.

11. Mr. Theobald had a much longer connection with the Department, for he was appointed an Assistant to the Geological Surveyor under the Bengal Government in 1849, that is, before Dr. T. Oldham came out to organise a regular service for the systematic geological survey of the whole country. The letter appointing Mr. Theobald on "a salary of Rs. 100 per mensem, including travelling allowance," was forwarded by a distinguished official still living, Mr. W. S. Seton-Karr. After being transferred for work under Dr. A. Fleming in the Salt Range, Punjab, Mr. Theobold was appointed Third Assistant on the Geological Survey of India under Dr. Oldham in 1853, and apparently employment was not regarded as a transfer, for his bill for "Cos. Rs. 714" for marching 1,428 miles from Jhelum to join his appointment was returned as "altogether inadmissible," and as a consequence the nature of his "employment" in the Punjab formed a subject of difficulty to the Financial authorities when Mr. Theobald applied for pension in 1881. With Theobald's death in March 1908 there passed away one more of the rapidly dwindling body of all-round Naturalists; his literary record in India covers all branches of Geology as then developed; he published papers on the structural features of different parts of the Punjab, Central India, Bengal and Burma; on palæolithic implements; on the petroleum, salt springs and the metalliferous resources of Burma; he paid special attention to questions of glaciation in the Himalayan region; published papers on fossil vertebrates as well as both fossil and recent invertebrates; and, although in his retirement he followed the work of his old Department closely and sometimes shared in the controversial questions that arose, his main energies were latterly devoted to the study of numismatics.

W. Theobald.

PUBLICATIONS.

12. The following parts of the *Records* were published during the year, containing the following papers and notes:—

Volume XXXVI, Parts 3 and 4.

Marine Fossils in the Yenangyaung Oil-field, Upper Burma, by E. H. Pascoe, M.A., B.Sc.

On the Occurrence of Fresh-water shells of the genus Batissa in the Yenangyaung Oil-field, Upper Burma, by E. H. Pascoe, M.A., B.Sc.

Volume XXXVII, Parts 1 and 2.

On the Occurrence of striated Boulders in the Blaini formation of Simla, with a discussion of the Geological age of the beds, by Sir T. H. Holland, K.C.I.E., D.Sc., F.R.S.

Note on Jurassic and Triassic fossils from Nepal.

The Tertiary and Post-Tertiary Fresh-water Deposits of Baluchistan and Sind, with notices of new Vertebrates, by Guy E. Pilgrim, B.Sc., F.G.S.

Notes on the Geology and Mineral Resources of the Rajpipla State, by P. N. Bose, B.Sc., F.G.S.

Report on the Suitability of the Sands occurring in the Rajmahal Hills for Glass Manufacture, by Murray Stuart, B.Sc., F.G.S.

Three new Manganese-bearing Minerals:—Vredenburgite, Sitaparite and Juddite, by L. L. Fermor, A.R.S.M., B.Sc., F.G.S.

Report on Laterites from the Central Provinces, by Prof. Wyndham R. Dunstan, M.A., L.L.D., F.R.S.

Miscellaneous notes on:—Hunza and Nagar Glaciers. Estuarine Deposit in Calcutta. Alunogen on a Meteorite.

Memoirs. The following Memoirs were published during the year:—

The Geology of the Persian Gulf and the adjoining portions of Persia and Arabia, by G. E. Pilgrim, B.Sc., F.G.S.

Upper Triassic and Liassic faunæ of the exotic blocks of Malla Johar in the Bhot Mahals of Kumaon, by Professor C. Diener, Ph.D., *Palæontologia Indica*, Series XV, Volume I, Part 1.

Ladinic, Carnic and Noric faunæ of Spiti, by Professor C. Diener, Ph.D., *Palæontologia Indica*, Series XV, Volume V, Memoir No. 3.

The Fauna of the Napeng Beds or the Rhœtic Beds of Upper Burma, by Miss M. Healey, *Palæontologia Indica*, New Series, Volume II, Memoir No. 4.

The Devonian Faunas of the Northern Shan States, by F. R. C. Reed, M.A., F.G.S., *Palæontologia Indica*, New Series, Volume II, Memoir No. 5.

On Some Fish-remains from the Beds at Dongargaon, Central Provinces, by Dr. A. Smith Woodward, *Palæontologia Indica*, New Series, Volume III, Memoir No. 3.

Sketch of the Mineral Resources of India, by T. H. Holland, D.Sc., F.R.S.

LIBRARY.

13. The additions to the Library during the period, 1st January 1908 to 31st December 1908, amounted to 3,946 volumes, of which 1,511 were acquired by purchase and 2,435 by presentation.

DRAWING OFFICE.

14. An important addition to the office equipment has been made for the purpose of turning out our own process-block reproductions. In spite of predictions of failure by those who knew of the dangers of attempting this work without special expert assistance, Mr. H. B. W. Garrick, the Artist of the Department, has turned out work that would be a credit to any institution, and he deserves great praise for this addition to a branch of work already brought to a creditable state of efficiency through his ability and unremitting work.

MUSEUM AND LABORATORY.

Staff.

15. Mr. H. Walker was Curator of the Museum and Laboratory up to the end of October, when he was given the work of revising the map of the Raniganj coalfield, Mr. G. H. Tipper taking over the duties of Curator. Mr. T. R. Blyth was Assistant Curator throughout the year, and the reports of the Curators regarding his work show that for earnestness and ability he has not changed: no greater praise could be given. Babu Bankim Behari Gupta, Museum Assistant for Palæontology, has continued to work most creditably, and his study of the fossil plants collected by Mr. Hayden in Afghanistan shows that he is capable of doing original work of a high order.

16. Dr. W. A. K. Christie, Chemist, continued the investigation of the resources of the Sambhar Lake, and worked out experimentally some problems raised by the Burma Oil Reserves Committee relative to the effect of varying pressure on the solubility of the heavier waxes in the lighter hydrocarbons of Burmese petroleum. He was chiefly engaged, however, in the investigation of the origin of the salt deposits of Rajputana. After exhaustive preliminary experiments made with the object of devising methods for testing the validity of the theory that the salt has been introduced by the hot-weather S. W. winds from the neighbourhood of the Ran of Cutch, he spent the hot weather in the Rajputana desert, sampling

the winds, rainwaters, sands, etc., the investigation of which, together with supplementary experiments on the efficiency of the methods and instruments used, occupied him for the rest of the year. The results of this work will be published separately and are summarised in another section of this report.

Determinative and Chemical work.

17. During the year, there was a decrease in the number of specimens referred to the Curator for determination. The number examined was 767, compared with 1,092 in 1907 and 786 in 1906. Of these, assays and analyses were made of 67, an increase of 22 on the previous year.

It is hoped that the new additions to the Laboratory will soon be completed, as in the present congested state it is very difficult to find accommodation for the students from Native States attached to the Survey. The extensions now being equipped have been obtained through the courtesy of Dr. N. Annandale in lending some of the rooms belonging to the adjoining office of the Superintendent of the Indian Museum.

Meteorites.

18. No meteoritic fall was recorded in India during the year, but the collection of foreign meteorites has been enriched—(1) by the addition of a piece (50 grams) of the Orgueil meteorite from the Musée d'Histoire Naturelle, Paris, through M. Stanislas Meunier, and (2) by a large slice of the Santa Rosa meteorite, received in exchange from Professor H. A. Ward.

Museum.

19. The work of replacing the old labels of the rock collections has been continued, and a handsome show case has been fitted up for the specimens of Indian coals.

Among the more interesting donations the following may be mentioned :—

1.—A fine block of *crocidolite schist* by Dr. E. THURSTON, C.I.E.

2.—*Monazite* } from Western Australia by P. C. RICHES, ESQ.
3.—*Tantalite* }

4.—*Cut gems* from Persepolis, Persia, by J. JOHANNES, ESQ.

5.—A fine series of *rocks and minerals from the Sudbury* and *Cobalt districts, Canada*, by DR. T. L. WALKER, Professor of Mineralogy at the University of Toronto.

The only new mineral added to the collection is Argyrodite, obtained by purchase.

EXHIBITIONS.

Nagpur.

20. In November Mr. L. L. Fermor was deputed to Nagpur in connection with the Central Provinces and Berar Exhibition, 1908, in charge of a collection of specimens illustrative of the mineral wealth of the Central Provinces, and to a smaller extent of other parts of India. The collection was accompanied by a selection of maps and diagrams. It was also part of his duties to collaborate with the Committee of the Mining Section of the Exhibition in the arrangement of the collections sent in by various mining companies and private individuals, and also to act as judge in awarding the medals for collections of minerals. In addition to the medals so awarded a special gold medal was awarded by the Committee of the Exhibition to the Geological Survey for their exhibit. The Exhibition aroused considerable interest amongst the mining community, and several collections were sent in, manganese naturally taking an important place; but coal, wolfram, copper, and other mineral substances were also well represented. One of the features of this section was an exhibit by some native gold washers, or *sonjharias*, from the Balaghat district of their methods of washing alluvial gold out of river sand. A full report, by Messrs. Fermor and Kellerschon, on the Mining Section of the Exhibition is being published in the *Transactions of the Mining and Geological Institute of India.*

Franco-British and Mining Exhibitions, London.

21. The Department was invited to send representative collections to the Franco-British Exhibition held at Shepherd's Bush and the Mining Exhibition organised by Mr. H. G. Montgomery at Olympia. The notice given was, however, too short to arrange for more than an exhibition of maps, photographs and publications. A short "Sketch of the Mineral Resources of India" was also prepared for the information of visitors to the Exhibitions. Mr. Hayden was present at the Mining Exhibition to supplement this information by answering enquiries. The exhibits of the Department were awarded a Grand Prix in each of the two classes 14 (Geography) and 63 (Working of Mines and Quarries).

MINERALOGY.

New manganese minerals.

22. The examination of the manganese-ore deposits of India carried out by Mr. L. L. Fermor during the last four years, and the subsequent study at headquarters of the material collected has led to the

discovery of several new varieties and species of minerals characterized by the presence of manganese in small or large quantities. Three of these minerals—winchite, blanfordite, and hollandite—have been noticed in previous reports. During the year under review accounts of three more of these minerals—vredenburgite, sitaparite, and juddite—have been published in *Records*, Vol. XXXVII, Part 2.

Vredenburgite.

Vredenburgite is a dark, steel-grey mineral of metallic lustre, with a bronze tint as seen in the sun. It has a hardness of 6·5, and a specific gravity of 4·74 to 4·84. Its most interesting property is its strong magnetism, for, broadly speaking, it is as strongly magnetic as magnetite. It has been found at two localities—Beldongri, Nagpur district, Central Provinces, and Garividi, Vizagapatam district, Madras. Although it is possible to interpret the analyses of this mineral so as to show the presence of Fe_3O_4 in the formula, yet the most simple formula is $3Mn_3O_4 . 2Fe_2O_3$. The discovery of such a mineral is perhaps disconcerting to the field mineralogist, for it means that when working in a manganese area, it will in future be unwise to assume that a strongly-magnetic, black mineral is magnetite, for it may be a merchantable ore of manganese.

Sitaparite.

Sitaparite is another bronze-tinted manganese mineral, but its bronze tint is much more pronounced than that of vredenburgite. It is found in the Sitapar manganese-ore deposit in the Chhindwara district. The hardness is about 7, and the specific gravity ranges from 4·93 to 5·09. It is most easily distinguished from vredenburgite, which it resembles somewhat closely in composition, by its being only feebly magnetic. The one analysis made gave as a result the somewhat complex formula $9Mn_2O_3 . 4Fe_2O_3 . MnO_2 . 3CaO$, assuming that the lime is an essential constituent of the mineral

Juddite.

Juddite is a variety of amphibole found in association with the manganese-pyroxene, blanfordite, at Kacharwahi in the Nagpur district. It is deep crimson as seen in hand-specimen; as seen under the microscope it shows perhaps the most beautiful series of pleochroic colours yet seen in any mineral. The following scheme is probably close to its true pleochroism :—

$\mathfrak{a}$ = carmine.
$\mathfrak{b}$ = blue with a lilac tinge, to pale green with a lilac tinge,
$\mathfrak{c}$ = orange or pinkish orange.

The mineral is further distinguished from most other varieties of the amphibole group by the position of its optic-axial plane, which is at right angles to the plane of symmetry.

PETROLOGY.

Singbhum, granophyres.

23. Whilst engaged in investigating the copper occurrences of Singbhum during January, February, and March, Mr. Fermor paid considerable attention to petrology of the Archæan rocks (gneissose granites, Dharwar schists, and intrusive basic igneous rocks) of the district. The most interesting petrological unit in the area is the complex of basic and acid igneous rocks forming Akarsani Hill near Kharsawan, represented by a pink patch on Ball's map of Singbhum and Manbhum, given in *Memoirs*, Vol. XVIII. The basic rocks are probably intrusive in the acid rocks, and of the same age as the other basic dyke-rocks intrusive in the Dharwar phyllites and schists of the area. The acid rocks are hypabyssal in character. They can be best described as *granophyres* and granophyric granite-porphyries. The most characteristic feature of the rock is the lilac-grey blebs of quartz, by which it can be distinguished, even when it has been rolled out into a schist, the roundish quartz phenocrysts being then represented by drawn-out lilac-grey streaks. A band of this rock has been traced for some 16 miles, to a point as far east as Gomharia, and there is no doubt, judging from the evidence obtained, that the rock is intrusive into the Dharwars. The rock is, however, so different from the main mass of the gneissose granite of Singbhum that its intrusive character cannot be taken as evidence that the common gneissose granites are also intrusive, although such is possibly the case.

Dalma trap.

24. Another interesting petrological unit in Singbhum is the *Dalma trap*, forming a range of high hills along the northern border of the district, and separating it from the Lohardaga and Manbhum districts. An examination of it at two or three points showed that it is of complex constitution, having folded up with it bands of Dharwar schists. In composition it consists mainly of varieties of epidiorites, representing, probably, corresponding original varieties of dolerite. In places it is found to contain small quantities of pyrite, chalcopyrite, and in one case pyrrhotite. Considering the epidioritic nature of the trap, it is probable

that the sulphides sometimes found in it are of secondary origin, although the metals they contain may have been contained in the original dolerites. It will need a very detailed examination to determine whether the Dalma trap is of contemporaneous formation with the Dharwar schists, or intrusive into them. The balance of evidence points to the latter view, and in this case it seems possible that the Dalma trap and the Akarsani granophyres may be respectively the basic and acid differentiation products of one original magma.

Magnesian rocks.

25. Some highly *magnesian rocks* have also been found in association with the Singbhum Dharwars. Such are the serpentines of Suru Pass near Chaibasa, in which chromite is found (which see), and the steatitic rocks of Turamdih, in which magnetite occurs (see under iron).

Central Provinces: the gondite series.

26. In Chapters XV to XVII of Volume XXXVII of the *Memoirs*, in the press during 1908, and issued in 1909, a comprehensive account is given of a series of rocks to which Mr. Fermor has given the name *gondite series*, after the aboriginal tribe of Gonds of the Central Provinces. The rocks of this series are supposed to have been formed by the regional metamorphism of manganiferous sediments deposited in Dharwar times. Where the sediments were fairly pure manganese oxides, the only result of metamorphism has been to consolidate them and convert them into crystalline manganese-ores (*primary ores*). But in cases where the chemically deposited manganese-oxide sediments were mixed with mechanically deposited sediments, such as clay or sand, metamorphism has brought about an interaction between the manganese oxides and the clay or sand, with the production in the former case of spessartite-garnet, and in the latter of rhodonite. The rock composed of a mixture of spessartite and quartz is known as *gondite*, and varieties of this rock containing other minerals are designated by qualifying terms; such as rhodonite-gondite, composed of rhodonite, spessartite, and quartz. Owing to the way in which the rocks of this series have been formed they tend to occur as banded masses, the bands representing original layers of different composition.

After these rocks were formed they seem to have been subjected to altering influences, probably waters containing oxygen and carbon dioxide, with the formation of manganese-ores. Such ores may be designated *deep secondary ores*. There are reasons for believing that this alteration of manganese-silicate to manganese-ore took place at the end

of the Dharwar period and that therefore, as in the case of the primary ores, the depth to which the deep secondary ores extend bears no genetic relation to the position of the surface of the ground. The rocks and associated manganese-ores of the Central Provinces are found developed typically in the Nagpur-Balaghat area, and also in Jhabua, Narukot, and Gangpur (see page 43). They are to be distinguished from the rocks of the kodurite series (see *Records*, Volume XXXV, page 22), which are of igneous origin.

PALÆONTOLOGY.

Palæontologist.

27. Mr. E. Vredenburg carried on the duties of Palæontologist throughout the year, and, in addition to his routine duties, continued his study of the Tertiary and Cretaceous collections.

Orbitolina.

28. Mr. E. Vredenburg has recorded an addition to our knowledge regarding the larger foraminifera of India, by his recognition of the important genus *Orbitolina*, which characterises rocks of Lower and Middle Cretaceous age and has not been previously recorded in India. (*Rec. Geol. Surv. Ind.*, XXXVI, p. 314). The Indian specimens were collected by Mr. Hayden between Gurez and Astor, in north-west Kashmir. The Geological Museum also contains specimens collected by Griesbach near Firaiman in Persian Khorasan. In either case the palæontological material is insufficient to establish the exact age of the *Orbitolina* bearing sandstones.

Marine Tertiaries of the Peninsular Coast.

29. In a note published in Volume XXXVI of the *Records* (page 321), Mr. Vredenburg has reviewed the available fossil evidence regarding the age of the Tertiary strata underlying the coastal laterite that forms an almost continuous belt round the peninsula. Concealed beneath lateritic and alluvial formations, these Tertiary beds have yielded fossils at very few points along the vast extent of their outcrop. The only instances recorded up to the present are the marine fossils discovered by Mr. P. N. Bose in Mourbhanj, the fossil wood of the Cuddalore sandstones, the marine fossils of the "Orbiculina beds" of Quilon, and an extraordinarily rich marine fauna discovered between depths of 115 and 145 metres during the sinking of an artesian well at Karikal. The mollusca from the Orbiculina beds have been partly referred to species occurring in the Gaj beds (Upper Aquitanian to Burdigalian) of North-Western

India. The marine beds in Mourbhanj contain an *Ostrea* closely related to an undescribed species from the Upper Gaj.

Out of 101 species so far described by Cossmann ("Faune pliocénique de Karikal," *Journal de Conchyliologie*, Volumes XLVIII, 1900, and LI, 1903) from the Karikal fauna, the richest Tertiary fauna as yet discovered in India, sixteen are identical with fossils from the Miocene of Java. The proportion of recent species in the Karikal fauna is 35 to 40 per cent. This figure agrees with the percentage of recent forms in the Miocene faunas of Java (35 to 50 per cent.) and Burma (30 to 48 per cent.). In the title of his work Cossmann has referred the Karikal fauna to the Pliocene (which, it should be remembered, for the author of the monograph as for many other geologists, includes the Pontian horizon). There seems no doubt that the Karikal beds belong to the same horizon as a portion of the Java and Burma series. Recent researches have tended[1] somewhat to lower the horizon ascribed to the Java beds [Douvillé, *Bull S. G. F.*, Vol. V (4), p. 435]. A much closer palæontological connection than was originally anticipated has also been detected between the Miocene beds of Burma and those of Western India, according to which the Burma series appears to range from Lower to Middle Miocene. This would therefore appear to be the approximate age of the Karikal fauna. It might of course reach into Upper Miocene if one adopts the system of classification that unites the Pontian with the Pliocene. This result agrees with the age indicated by the Mourbhanj fossils and by those from the "Orbiculina beds," and suggests that the Tertiaries in the Coastal System all belong to one period. Yet this palæontological evidence, however satisfactory, is so local as compared with the vast extent of the coastal outcrop that it would be unsafe to generalise from these results.

Bagh beds : ammonites.

39. The Bagh beds first discovered by Keatinge in 1857 are of particular interest as a marine representative of the fluviatile Lameta or "Infra-trappean" series. Their total thickness is insignificant, but they have escaped denudation owing to a protective covering of Deccan Trap, and can be followed up the valley of the Narbada from the plains of Gujrat to Barwaha, some 240 miles from the sea-coast. Among the fossils collected by Keatinge, Blackwell, Blanford, and Bose, the echinoids studied by Duncan were found to include several species known from the Cenomanian beds of other lands, such as *Salenia Fraasi*, *Cyphosoma cenomanense*, *Echinobrissus Goybeti*, *Nucleolites similis*, *Hemiaster cenomanensis*, *H. similis* (*Quar. Jour. Geol.*

Soc., Vol. XXI, p. 349, 1865; *Rec. Geol. Surv. Ind.*, XX, page 81, 1887). This palæontological evidence suffices for referring the Bagh beds to the Cenomanian.

The ammonites collected from these same beds by Mr. P. N. Bose during the years 1880 to 1883 form the subject of a paper by Mr. Vredenburg, published in Volume XXXVI of the *Records* (pages 109 to 125). They belong to three species previously undescribed, which Mr. Vredenburg has named *Placenticeras Mintoi, Cœlopoceras Scindiæ*, and *Cœlopoceras Bosei*. Being all three new species, they do not add any further weight to the palæontological evidence furnished by the echinoids, at the same time not clashing with it, since *Placenticeras Mintoi* belongs to a group of forms abundantly represented from the Gault to the Lower Senonian, while the species of *Cœlopoceras* so far described are attributed to the Turonian.

The *Placenticeras* specimens are very numerous in Mr. Bose's collection. This ammonite, originally regarded by Feistmantel and Bose as identical with *Pl. tamulicum* from the Trichinopoli beds of South India, has been found to belong to a distinct species, which Mr. Vredenburg has described under the name *Placenticeras Mintoi*.

In comparing the Bagh *Placenticeras* with previously described species, Mr. Vredenburg has been led to classify the members of the genus into four groups distinguished from one another by the gradually increasing complexity of the suture line. The simplest suture is that of *Pl. Warthi* of the Muravatur beds of South India; the group of *Pl. Fritschi* includes a number of species ranging from Gault to Lower Senonian; *Placenticers syrtale*, with its numerous varieties, characterises the Santonian; the newest group, that of *Pl. placenta* with excessively ramified sutures, characterises the Campanian. *Placenticeras Mintoi* belongs to the numerous group of forms related to *Pl. Fritschi*, whose geological range is very extensive.

The two other ammonites *Cœlopoceras Scindiæ* and *C. Bosei*, included in Mr. Bose's collections, are each represented by a single fragment. They represent a generic form closely related to *Placenticeras*, for which Mr. Vredenburg proposed the name *Namadoceras*. Subsequently to the publication of his paper, Mr. Vredenburg noticed that his generic diagnosis coincides with that of Hyatt's genus *Cœlopoceras* (*Rec.*, Vol. XXXVI, p. 239). The American species of *Cœlopoceras* occur in the Colorado group which is regarded as Turonian. The European *Ammonites Requieni*, which Mr. Vredenburg regarded as closely allied to the Bagh fossils, and which is likewise referred to *Cœlopoceras*

by Hyatt, is also Turonian. If the two Bagh ammonites are included in the same genus, the range of *Cœlopoceras* must be extended downwards into the Cenomanian.

Molluscan fauna of the Ranikot series.

31. Mr. Vredenburg's translation of Messrs. Cossmann & Pissarro's description of the Molluscan fauna of the Ranikot in Sind, the publication of which had to be postponed owing to the preparation of the Illustrations to the stratigraphical introduction, will shortly appear.

The Ranikot strata in Sind are the only authentic representatives of the Lower Eocene so far known in India, and their interest is further increased by their extremely restricted extent. Compared with the enormous development of the Middle Eocene of India, the area occupied by these Lower Eocene beds is quite insignificant, more so even than would appear from the original maps published by Blanford and Fedden : the area as first defined has been considerably reduced in consequence of the withdrawal of the "Meting shales" which were originally incorporated in the Ranikot, but which the palæontological and stratigraphical researches of Mr. Vredenburg have shown to be separated from the Ranikot by an unconformity, and connected with the overlying Laki stage of Middle Eocene age. The removal of the Meting shales curtails the outcrop of the Ranikot, as originally mapped, by nearly 200 square miles. This leaves only some 276 square miles as the total area of the Lower Eocene outcrop of which less than 200 square miles belong to the Upper Ranikot with marine fossils, the Lower Ranikot yielding nothing but plant remains, with the exception of a thin oyster-bed occasionally present at its lowermost limit.

In a previous volume of these *Records* (Vol. XXXIV, pp. 85—94 and 172—198), Mr. Vredenburg has indicated the possibility of recognising four principal zones in the Upper Ranikot, the uppermost of which contains the species *Nummulites planulatus*, indicating its approximate correspondence with the "Sables de Cuise." According to the scheme of correlation advocated by Mr. Vredenburg, the underlying zones approximately correspond with the horizon of the London Clay. One of the papers above referred to contains a tabular representation of the distribution of the echinoids within these four zones. In the stratigraphical introduction to Cossmann and Pissarro's description of the molluscan fauna, Mr. Vredenburg has reproduced this list, and has also added a similar table giving the zonal distribution of the Ranikot corals originally described by Duncan (*Pal. Ind.*, Ser. XIV, part 2). In the

case of the echinoids and corals, the distribution of the described forms through the successive zones, or at least through the three upper ones, is fairly even, though the species represented in the uppermost zone (zone 4 of Mr. Vredenburg's classification) are somewhat more numerous owing to the greater richness of the collections from this upper horizon. Comparatively scanty collections have been obtained from the three lower zones, whose outcrops are situated in a region rendered somewhat inaccessible from the want of drinking water.

In the case of the Mollusca, the preponderance of material from the uppermost zone is so overwhelming that an attempt to represent the zonal distribution of these fossils in tabular form would be premature. Amongst the materials available for study, by far the greater proportion represents the collections gathered from the uppermost zone by Mr. Vredenburg in 1900 in the neighbourhood of Jhirak, at places very rich in molluscan remains, but which have added nothing of importance to the previously described echinoids and corals. The zone of *Nummulites planulatus* includes no less than 73 out of 100 forms described by Messrs. Cossmann and Pissarro ; 53 of these are restricted to the uppermost zone, but this large proportion is due to its preponderating share in the available collections.

The fossils so far described by Messrs. Cossmann and Pissarro include the Cephalopoda, Gastropoda, and Scaphopoda. Out of a total of 100 species, 22 had already been described by d'Archiac and Haime in their classical monograph on the Tertiary fauna of India. The remaining species are all new to science. There are no instances of identity with European fossils, though the relation of certain species to Eocene fossils from Europe or other areas, even as far distant as North America, is sufficiently close for them to be regarded as representative forms. Certain genera or sub-genera (*Alocospira*, *Aulicina*, *Volutoconus*) absent from the European Tertiaries, exhibit Australasian affinities.

The *Cephalopoda* include the genera *Belosepia*, *Styracotheutis*, *Nautilus*. The species *Styracotheutis orientalis* Crick, very abundant in the uppermost zone, is particularly interesting as an example of one of the last of the extinct group of the belemnites, intermediate in its characters between the Upper Cretaceous genus *Belemnitella*, and the Eocene genus *Vasseuria*. The species was originally described from a specimen collected on the Oman coast of Arabia, thereby indicating the presence of Lower Eocene beds along the Arabian as well as along the Indian shores of the Arabian Sea.

Amongst the *Gastropoda*, the *Opistobranchia* are represented by the

genera *Tornatellæa, Bulla, Acera.* Of the various families of the *Prosobranchia,* those most abundantly represented are the *Pleurotomidæ* (10 species), *Volutidæ* (8 species), *Strombidæ* (9 species), *Turritellidæ* (6 species), *Naticidæ* (13 species). The species of *Strombidæ* in particular are represented by numerous specimens. Amongst species that are particularly abundant may be mentioned : *Surcula Voyseyi* d'A. and H. (zone 4), *Volutospina Sykesi* d'A. and H. (all horizons), *Cassidaria Archiaci* C. and P. (zone 4), *Gisortia Murchisoni* d'A. (zones 2 to 4), *Calyptrophorus indicus* C. and P. (principally zone 1), *Rimella Prestwichi* d'A. and H. (principally zone 4), *Terebellum distortum* d'A. and H. (zones 3 and 4), *Terebellum plicatum* d'A. and H. (zones 3 and 4), *Chenopus dimorphospira* C. and P. (zones 3 and 4), *Rhinoclavis subnuda* d'A. and H. (zones 2 to 4), *Rhinoclavis angystoma* d'A. and H. (zones 2 to 4), *Turritella angulata* J. de C. Sow (all horizons), *Mesalia Mecquenemi* C. and P. (zones 2 to 4), *Ampullina sindensis C.* and P. (zones 2 to 4), *Ampullina aulacospira* C. and P. (zones 2 to 4), *Velates Noetlingi* C. and P., closely related to the European fossil *Velates Schmideli* (zones 2 to 4), *Delphinula Cordieri* d'A. (zone 4).

Nummulites Vredenburgi Prever.

32. In describing an interesting nummulite from the eocene of north-western India under the name *Nummulites Douvillei* (*Rec., Geol. Surv. Ind.,* Vol. XXXIV, pp. 79—95, 1906) Mr. Vredenburg was unaware that this name was pre-occupied by a species from the Appenrires described by Dr. Prever in a monograph which was not then available in the library of the Geological Survey (*Mem. Soc. Pal. Suisse,* Vol. XXIX). Dr. Prever has proposed to substitute the name *Nummulites Vredenburgi Prever,* for the Indian fossil (*Rec., Geol. Surv. Ind.,* Vol XXXVI, p. 239).

Liassic and Neocomian of Baluchistan.

33. Mr. G. H. Tipper has nearly completed an account of the Liassic and Neocomian fossils of Baluchistan. The collections which form the basis of his report were obtained mainly during the field-season 1905-06, while surveying the Native States of Kalat and Las Bela in Baluchistan. But there are also included collections made previously by Mr. Vredenburg in the vicinity of the Takatu, and by Lala Kishen Singh, late Sub-Assistant, from near Kalat. In 1907-08, while on study leave at Cambridge, Mr. Tipper made a preliminary examination of the whole of the material and a direct comparison was made with the chief European fossils. The detailed examination,

continued since, so far as other duties have allowed, has given the following results.

The divisions suggested from the study of the deposits in the field have been fully borne out; that is, the Baluchistan Lias may be divided into Lower, Middle and Upper. The character and distribution of these three are roughly as follows:—

Liassic fossils.

Lower Lias.—Crinoidal Limestones and shaley beds. Shirinab valley, south of Mastung.

Middle Lias.—Black limestones of the Takatu. Oolitic limestones and shales of Sarawan and Northern Jhalawan. Black shales and limestones of Southern Jhalawan and Las Bela.

Upper Lias.—Black shales of the Natrani river, Las Bela.

The Lower and Upper Lias are but poorly developed, while the Middle includes almost all the exposures examined in Sarawan, Jhalawan and Las Bela.

The place of the lower and upper divisions is readily established by the fact that they have yielded ammonites closely related to, if not identical with, well-known European forms. Thus the Lower Lias has yielded *Arictites sp. aff. bisulcatus.* The presence of this fossil shows that only the lowermost zone is represented. Other fossils are by no means well preserved, and their affinities cannot be made out with satisfaction.

The Upper Lias of the Natrani river yielded a rich collection of ammonites, which, although not very well preserved, are yet good enough for their affinities to be made out. The following species have been recognised:—

Harpoceras cf. serpentinum
Dactylioceras cf. annulatum.
Hildoceras sp.
Oxynotoceras sp., young form.

These forms are typically Upper Liassic in age. All these ammounites were weathered out and collected from one gentle dip-slope, so that the whole of the Upper Lias in this locality is crowded into a thin band of shale. The only other fossil found associated with these ammonites is a *Spiriferina*, which occurs in large numbers. This graceful ribbed form with a rather high area is distinct from any described form, and is undoubtedly new.

The Middle Lias has yielded a very rich and interesting fauna, in which unfortunately ammonites are very rare, and exact correlation is a matter of difficulty. There are three areas where the Middle Lias is well developed, and, as these areas seem to correspond to differences in fauna, they may be treated separately. The faunistic differences may be more apparent than real and are probably due to hurried collecting. The areas may be designated (1) the Takatu, (2) Sarawan and Northern Jhalawan, (3) the Porali river.

Taking them in order, the Takatu area has yielded a fauna rich in numbers, but poor in species. It includes among the brachiopods *Spiriferina nov.* sp. No less than 989 specimens of this species occur. Although there is a considerable variation among them, yet it is not definite, and the specimens cannot be grouped except as a whole. Specimens of this species are small in size and generally smooth. Those specimens which have passed maturity show faint ribs, and are much stouter in habit than the young and mature forms.

Spiriferina rostrata Schloth. There are several specimens which may be referred to this species.

A single specimen of a peculiar *Spiriferina* occurs. It is extremely broad and very thin. Although very distinct, it is probably a sport and not a new species. Under the designation *Terebratula synophrys* Uhlig, *T. pacheia* Uhlig and *T. synophrys* var. *polyptycha* del Piaz. may also be included. All these forms occur, and are to be considered as variations of the type form. The young of this species is quite smooth.

The occurrence of *Eudesia* sp. in the Lias of Baluchistan must be considered as one of its chief peculiarities, as elsewhere it is not found at a lower horizon than the Inferior Oolite. This genus occurs in considerable numbers, not only in the Takatu area, but also to the south. Several specimens closely related to the European form *Rhynchonella tetraëdra* Sow. occur. Of the lamellibranchs, the chief representative is the genus *Pecten*, with two species, the first related to *Pecten* (*Aequipecten*) *æquivalvis* Sow., and the second to *Pecten* (*Entolium*) *hehlii* d'Orb.

The rich and varied fauna of the Sarawan and Northern Jhalawan area has not been thoroughly worked out yet, but the following are the most interesting points :—

(1) The presence of the genus *Eudesia*, represented by a species different from that of the Takatu area.

(2) The occurrence of a very peculiar *Pecten*. This at first sight

resembles *P. alatus* von Buch of the Lias of South America, but it differs in several important particulars; the ribs are more numerous, angular and bear distinct spines, and during part of its life it was fixed by the left valve. This has led to the formation of a distinct angle, the upper part flat or concave and the lower, convex. The appearance of this *Pecten* is so striking that it is used as a charm by the inhabitants of Jhalawan.

Spiriferina di Stefanoi del Piaz found in this locality, is a species with a high triangular area and peculiar ornamentation, according to Dautzenberg it ought to be raised to subgeneric rank. The occurrence of a new genus of echinoids is also of considerable interest. This and the remaining forms will be described in Mr. Tipper's memoir. No ammonites were discovered in this area.

The Porali river area is particularly interesting, not only on account of the splendid preservation and number of the fossils, but also because many of them closely resemble Liassic fossils from Madagascar recently described by Thevenin in the *Annales de Paleontologie*, tome III, fasc. III. Thevenin describes a Middle Lias fauna comprising, among other forms, a new genus of ammonites, *Bouleiceras*, *Pecten ambongoensis*, and *Spiriferina rostrata* var. *madagascarensis*. These three forms can be matched from the Porali river collection. At the time of collecting three well-preserved fragments of an ammonite were obtained and at once recognised from the peculiarity of the suture as probably new. There is now very little doubt that they belong to the genus *Bouleiceras*. *Pecten ambongoensis* can also be matched by a number of specimens. This pecten belongs to the same class as, and is closely related to, that already mentioned as occurring in the northern area. Thevenin's figures show perfectly the distortion of the left valve by the attachment area. This latter fact is sufficient to distinguish it from any other pecten, and if Mr. Tipper's suggestion is correct, that it is due to fixation during part of its life, it ought to be raised to subgeneric rank. Similarly with *Sp. rostrata* var. *madagascarensis* and its different forms figured by Thevenin, these three examples as well as and many others show the close resemblance of the Porali river fauna to that of Madagascar.

Of the other forms occurring may be mentioned :—

Lima cf. punctata Sow.
Lima (Plagiostoma) gigantea Sow.
Pholadomya cf. idea d'Orb., and many others.

Neocomian.

34. The opportunity was also taken by Mr. Tipper, while on study leave, of examining a small collection from the Belemnite Shales, a formation very widely developed in Baluchistan. The age of these shales was fixed by Dr. Noetling as Neocomian from the presence of *Belemnites* (*Duvalia*) *dilatata* Blainv. The known fauna is so small that any additions are of interest. Broken and unidentifiable ammonites have been collected by several observers, but the field-season 1905-06 yielded several well-preserved specimens. They have been identified as follows :—

Hoplites amblygonius Neum.—One specimen agreeing perfectly with Neumayr's species.

Olcostephanus sp., group of *O. asterianus*.—Although not specifically identifiable, there is no doubt that it belongs to this group.

Perisphinctes ? sp.

Phylloceras cf. velledæ d'Orb.

Phylloceras sp.—Young form, perhaps the young of *Phyll. cf. velledæ.*

Crioceras sp.

In addition occur fragments of *Aptychi*, belonging to the groups *imbricati* and *punctati* of Zittel. This association is typically Neocomian, and bears out Noetling's correlation. From the presence of *Hoplites amblygonius* and *O.* sp. group of *asterianus*, the fauna may be considered as belonging to the Volgian type.

Tertiary of Upper Burma.

35. Messrs. E. H. Pascoe and G. de P. Cotter have added considerably to our knowledge of the palæontology of the oil-bearing Tertiary strata in Upper Burma. Mr. Cotter has identified the collections made by the late Mr. L. G. Boyd of the Burma Oil Company in the Pegu series of Singu, Payagyigon-Ngashandaung, Padaung (near Prome), Kabat in the Myingyan district, Taungtha hill and hills near Kwatalin, 20 miles south of Taungtha. The lists of species from each area are given in *Records*, Vol. XXXVI, pp. 131 and 132.

Pegu beds.

36. During the field-season 1906-07, marine fossils were found for the first time in the Pegu (Miocene) beds of the Yenangyaung inlier, occurring at two horizons. Neither of these corresponds well with any of Dr. Noetling's zones, but the discovery proves that although the Pegu beds at Yenangyaung are less fossiliferous than at Singu, Yenangyat or

Minbu, they were deposited under similar conditions. The questions are discussed by Mr. Pascoe in a paper published in the *Records* (Vol. XXXVI, Part 3). Among other fossils described Mr. Pascoe gave a provisional name, *Twingonia*, to a fairly abundant form then regarded as of doubtful zoological affinity but since identified as fish otoliths.

Freshwater fossils in the Pegu beds.

37. In addition to the classical locality, east of Minlindaung, from which specimens of the freshwater forms *Batissa crawfurdi* and *B. petrolei* were first obtained by Crawford ninety years ago, Mr. Pascoe has found two others in which these two species occur and one yielding the gigantic *B. kodaungensis*. Distorted specimens of a variety of *B. crawfurdi*, named *yedwinensis*, have also been found in the Pegu beds, 300 feet below the Pegu-Irrawaddi boundary, thus pointing to the local, temporary establishment of freshwater conditions. These occurrences have been described by Mr. Pascoe in a special paper (*Rec., Geol. Surv. Ind.*, XXXVI, Part 3).

Dendrophyllia.

38. Messrs. Pascoe and Cotter have described and figured (*Rec. Geol. Surv. Ind.*, XXXVI, Part 3, p. 147), a new species of the coral *Dendrophyllia*, *D. macroriana*, found in the Singu and Minbu fields.

Estuarine beds under Calcutta.

39. The occurrence of an estuarine bed under Calcutta was described by Mr. E. Vredenburg in 1904.[1]

Dr. N. Annandale, Superintendent of the Natural History Section, Indian Museum, has since identified the animal remains found. Most of the specimens collected are remains of molluscs, including *Telescopium fuscum* Ch., *Paludina* (*Vivipara*) *bengalensis* Lam., *Ampullaria globosa* Swains, *Aricia* (?) *moneta* Linn., *Planorbis exustus* Desh., *Anomia achæs* Gray, *Arca adamsiana* Dkr., *Ostrea cucullata* Bow., and *Ostrea canadensis* Tk. All these can be identified with living species, either in the freshwater tanks, in the brackish estuarine distributaries of the Ganges, or, in one case, in the clear sea-water. The most interesting is the last-named oyster, which seems to have had a wide distribution, for the specimens found are not, as once suggested, imported to Calcutta as ship's ballast, the same species being found still living and common in the Sunderbans.

Lameta Fossil Fish.

40. An occurrence of Lameta beds at Dongargaon in the Central Provinces was long ago brought into prominence by Hislop's discovery of fossil

[1] *Rec., Geol. Surv. Ind.*, Vol. XXXI, p. 174.

fish-remains. Recently some of the specimens collected at this locality came into possession of the Geological Survey, and Dr. A. Smith Woodward has now completed their examination (*Palæontologia Indica*, New Series, Vol. III, No. 3). All the remains appear to differ in specific characters from previously known forms, and three species have been distinguished. One of these, a Teleostean, is sufficiently strange to constitute a new genus, *Eoserranus*, while of the other two one is especially interesting, as it is the first-described specimen of the remarkable genus *Lepidosteus* that has been found in Asia, Dr. Woodward's description thus confirming Hislop's suspicion regarding the occurrence of this genus in the Lameta beds. All three genera have their nearest known relatives in the early Tertiary rocks of Europe and America. No true Percoid fish has been found hitherto in typical Cretaceous strata, and the oldest known member of the group to which *Eoserranus* belongs is *Prolates* of the Montian stage in France. *Lepidosteus* also ranges from the Lower Eocene to the Lower Miocene in Europe and from the Lower Eocene to Recent in North America, while the third genus, *Pycnodus*, represented in this collection has not been found outside the Eocene. Thus, judging by the evidence of the fossil fishes alone the age of the Lameta bed from which they were obtained would be between the Danian and Upper Eocene.

Gondwana plants, Pench valley.

41. Captain F. L. Ditmas and Mr. S. D. Ware have sent to the Museum some fossil plants collected in the Pench valley coalfield between the villages of Dongor Porashea and the boundary of the Deccan Trap, north of the village of Hurreye. The specimens were obtained in an area marked as Barakar on the map accompanying the late Mr. E. J. Jones' memoir on the Satpura coalfields (*Mem., Geol. Surv. Ind.*, Vol. XXIV, Part 1), but according to the donors the beds are above the coal measures. The collection, identified by Babu Bankim Behari Gupta, Museum Assistant, includes *Phyllotheca indica* Bunb., *Glossopteris indica* Schimp., *Gangamopteris cyclopteroides* Fstm. and several other forms apparently new. The material identified is hardly sufficient to settle the age of the beds, and it is hoped that further discoveries of fossil plants in this area will be made in order that the Pench valley beds may be compared with the Mohpani coalfield, which, on the other side of the Satpura basin has yielded Karharbari plants.

ECONOMIC ENQUIRIES.

Alum.

Mianwali District, Punjab.

42. Mr. N. D. Daru was deputed to the Isakhel tahsil, Mianwali district, Punjab, early in the year to report on the indigenous industry of alum manufacture and on the pyritous shales which were considered to be of possible value for the manufacture of sulphuric acid.

At Kalabagh the total length of the shale outcrop is about a mile and a half, with an average thickness of eight feet. About the same length of outcrop is accessible at Kotki, but the average thickness is four times as great, and the shale bed extends for eight miles east of Kotki. Patches only in the shale have been found to be rich enough for working. In these the average sulphur-content is 9·5 per cent., and there is besides bituminous matter present to the extent of about 3 per cent. The pyrite which mainly contributes to the sulphur-content is as a rule extremely comminuted, and can be distinguished only under the microscope. There is just a trace of gold in the shale. The shale is fissile to compact, light-gray to deep-black, and breaks with a conchoidal fracture. When freshly-mined it will take finger impressions, and when containing bituminous matter it has a greasy feel and can be easily given a lustre.

There is no systematic mining. The mines often are narrow, low, tortuous passages or screw-shaped shafts, and do not reach below the level of the adjoining springs. There is no provision for ventilating these hot mines and timbering is rarely found necessary.

At Kalabagh the alum manufacturer pays one rupee for twenty-five maunds of the shale; one-third of this amount going to the Malik of Kalabagh as royalty. At Kotki, the price is 35 maunds to the rupee, all of which goes to the miner.

The shale is roasted in the open, and there is considerable loss of sulphur dioxide. In roasting, the fresh shale is mixed with an equal quantity of previously used, but not quite exhausted, shale, which has been subjected to spontaneous oxidation for a year or more. The roasting is continuous, portions of the heap being cut away on one side to supply the works, and fresh and old shale

added on the other. Owing to the low sulphur-content, fuel has to be used.

The roasted shale is lixiviated, allowed to settle, and then boiled. When sufficiently concentrated, a mixture of crude chlorides, nitrates and sulphates of sodium (chiefly) and of potassium, is added, and the liquor transferred to crystallization tanks. When the crystals from these are removed after a week, the mother liquor is added to the fresh liquor from the roasted shale in the lixiviation tank. The crystals are allowed to accumulate for ten days, when they are fused in their water of crystallization, and the melt is poured into earthenware pots sunk into the ground. When it has recrystallized, the alum is ready for the market. The alum is mainly sodium-alum with a small proportion of potassium-alum. It goes to Delhi, Hissar, Sirsa and other centres of tanning and dyeing industries. The price of alum at Kalabagh in February 1908 was Rs. 4-12-0 a maund, and at the end of March 1908 it was Rs. 4-8-0.

The practice at Kotki is essentially the same as at Kalabagh. The output was 16 maunds a day at Kalabagh, where only one factory (which had been restarted on a rise of price of alum in November 1907 to Rs. 5 per maund) was working; at Kotki, each of the three factories, which work for only six or seven months in the year, has a daily output of 25 maunds. The annual output of Isakhel Tahsil may be put roughly at 20,000 maunds or 750 tons. Kalabagh, in spite of the high cost of shale there, can compete with Kotki owing to its proximity to the Indus and the railway, whereas Kotki manufacturers have to haul in part of their alkaline salts and haul out the whole of their alum output, by camel transport over a distance of nearly ten miles.

Improvements in the manner of roasting the shale, and in the construction of the fire-chamber for the boiling-pans are desirable. What is of perhaps greater importance still is the abandoning of the use of lime in the linings of the various tanks, and the substitution of plaster of Paris for it, there being plenty of gypsum near at hand. This change would probably prevent a waste of over six rupees' worth of the acid at each factory every day.

The alkaline salts come from Mandakhel and Kamar-Mashani in the Isakhel Tahsil, Rokhri and Thatli near Mianwali, and Shahpur. At the first two places they are obtained by

concentrating and crystallizing the product of lixiviation of the scrapings of the soil of the neighbourhood.

Dandot.

43. Mr. Daru visited the Dandot Colliery of the North-Western Railway, where pyritous shales are also known. The shale here, on account of its high carbonaceous contents, is unfit for acid-making, but can be used for alum-making more advantageously than the shale of Isakhel Tahsil. The markets are 125 miles nearer, the source of the best alkalies is only half as distant as from Kalabagh.

China-clay.

Rajmahal Hills, Bengal.

44. In addition to an examination of the sands supposed to be of value for glass-making, Mr. Murray Stuart paid special attention to the clays of the Rajmahal hills said to be suitable for the manufacture of china and porcelain. Good material was found at three localities on the west of the hills, namely, Paturghatta near Colgong, Buskia near Katungi (24° 28′; 87° 29′) and Dodhanee (24° 17′; 87° 29′). There is evidence at the first-mentioned locality that the kaolin is of wide extent and that the quantity, speaking from a manufacturer's point of view, is unlimited. The quality of the clay is good, and it resembles strongly the Cornish china-clays. The extent of the deposits of kaolin at the other two localities is undetermined, but there are indications that there is a fair quantity at each place. In quality the clays from the last two localities seem to be equal to that of the clay obtained from Paturghatta.

In addition to these deposits, kaolin occurs in the white Damuda sandstone of the district and it is being extracted from the same sandstone at Mangal Hat near Rajmahal for use by the Calcutta Pottery Company. In quality it seems to be good and at Mangal Hat it is obtained very free from mica. On the west of the hills, however, the Damuda sandstone is more micaceous, and therefore would not be so suitable for the extraction of kaolin. Mr. Stuart's full report will be published in the *Records*.

Chromite.

Singbhum, Bengal.

45. In April Mr. Fermor paid a visit to an occurrence of chromite discovered in a serpentine at the Suru Pass on the road from Chaibasa

to Sonua, B. N. R., by Mr. R. Saubolle, prospecting on behalf of Messrs. Martin & Co. of Calcutta. Twelve small excavations had been made, and from each chromite had been obtained. In three of them the chromite was seen *in situ;* it occurs as bed-like veins and disseminations in serpentine. These veins range up to about 10 inches in thickness, and in one of the pits formed a network. The junction between the chromite and the serpentine is usually sharp, but some specimens show a passage from chromite with very little serpentine, through serpentine containing disseminated grains of chromite, to serpentine practically free from chromite. The ore is of fairly high grade. A sample taken from the little stacks of ore—perhaps 10 tons in all—lying by the side of each opening yielded 50·05 per cent. of sesquioxide of chromium Cr_2O_3. Further prospecting has led to the discovery of other occurrences of chromite in this area; but none has yet been proved to be of commercial value.

Copper.

Singbhum, Bengal.

46. During the field season of 1907-08, geological and mineral work in Singbhum was continued by a party, consisting of Messrs. L. L. Fermor and K. A. K. Hallowes, with two students, Mr. G. G. Narke of Nagpur and Babu Kiran K. Sengupta of Calcutta, who were being instructed in methods of field-work. Mr. Fermor's time was spent in making a general examination of the ground with reference to the origin and mode of occurrence of the copper deposits, the relationships of the various rocks one to another, and the examination of various mineral deposits other than copper. The various portions of his work are noticed under petrology, chromite, iron, and manganese. With regard to the mode of occurrence and origin of the copper deposits he is in more or less general agreement with Mr. Hallowes' conclusions and descriptions, as embodied in his progress reports.

Mr. Hallowes took up his work where he left it in the previous season, namely, at Matigara in Dhalbhum, and continued the examination of the copper belt to the south-east and south-south-east as far as Bhairagora near the Mourbhanj border, beyond which locality he was not able to find any further old copper workings; all his work this season thus lay in the Dhalbhum Estate. Old copper workings are now known to occur at intervals along a belt

stretching for some 80 miles from Duarparam on the Bamini River in the Kera Estate on the extreme west, through the Kharsawan and Saraikala States. So far the general trend of the belt is practically due east; but on entering the Dhalbhum Estate, within which it lies for the remainder of its course, at Landup the strike of the belt curves round to south-east, running through the Rajdoha and Matigara properties of the Rajdoha Copper Company, Limited, and then through the wild south-east portions of Dhalbhum to Bhairagora, at the extreme south-east end of the belt. This curving round of the strike is an expression of the fact that throughout its course the strike of the copper belt follows that of the Dharwar schists and phyllites in which the copper deposits occur; the strike of the Dharwar rocks themselves is determined by the shape of the enormous area of granite occupying central and southern Singbhum, as they dip away from it everywhere.

The copper-ores occur as rather indefinite lodes interbedded with the Dharwar phyllites and schists; sometimes the ore is collected into fairly well defined bands, but very frequently it occurs in the form of grains disseminated through a considerable thickness of schists so sparsely as to be unworkable; whereas if the same amount of copper minerals had been concentrated into smaller thickness of schists workable deposits of ore would have been formed. When concentrated into definite lodes, as at Matigara, the ore may be of fairly high grade, and well worth working if it can be proved to exist in sufficient quantity to render it worth while to erect the plant necessary to handle large quantities of ore. The development work being carried out from the Gladstone shaft in the Matigara mine by the Cape Copper Company, on an option held from the Rajdoha Copper Company, has given somewhat encouraging results, but, until a considerably larger amount of drilling and underground development has been accomplished, it will not be possible to speak with certainty of the prospects of this mine. As seen at the outcrops the lodes seem to be very poor indeed, where they have not been removed by the ancients. Typically, they consist of small thicknesses of vein quartz, associated with malachite, chrysocolla, and red oxides of iron containing a small qunatity of copper, possibly as red oxide, with sometimes small encrustations of liebethenite. In depth, as seen in the diamond-drill cores and the levels of the Matigara mine, the ores consist practically entirely of chalcopyrite. The other

minerals noticed above are evidently the outcrop alteration products of the yellow sulphide. Judging from small specimens found on the dump heaps of the old workings there must be a zone of chalcocite not very many feet below the surface, probably formed by secondary enrichment at the expense of the portions of the deposits denuded away, and of those now appearing as gossans of oxide ores. The primary chalcopyrite ores have probably been deposited in their position as rather indefinite lodes following the bedding of the schists, subsequent to the arrival of the schists in their present position. The schists with which the copper lodes are associated are chiefly varieties of muscovite and chlorite-quartz-schists, with quartzite layers. Apatite and tourmaline are also common minerals in these schists.

The diamond drilling accomplished during the year included :—

(*a*) *Matigara*, three miles west of Moholia, B. N. R., in the Dhalbhum Estate. This hole was put down to a depth of 837 feet to test the extension in depth of the lode exposed at a depth of 229 feet in the Gladstone shaft, the Cape Copper Company bearing half the expense of the hole. The most valuable portion of the lode was cut at a depth of 736 feet from the surface, but the rocks were cupriferous for a vertical distance of 46 feet. (dip of lode =38°). The cores were assayed in sections by Mr. Hallowes with the following results :—

Portion of core.	Actual thickness.	Copper.
693′—697′	3·15′	2·0 per cent.
697′—701′ 8″	3·67′	1·29 „
733′ 5″—736′ 1″	2·10′	1·01 „
736′ 1″—736′ 5″	0·26′	12·81 „
736′ 5″—739′	2·03′	0·42 „

(*b*) *Laukisra*, to the south-west of Ghatsila in Dhalbhum. This hole was put down to a depth of 392 feet to test a lode indicated by some old workings. The cores were found to be noticeably cupriferous between the depths of 150 and 184 feet. Taking the dip of the rocks as 21° the thickness of cupriferous rock or 'lode' is about 23 feet. The lode was assayed by Messrs. Snelus and Duff of the Cape Copper Company, with the following results :—

Position of core.	Actual thickness.	Copper.
150′—168′	16·80′	2·65 per cent.
169′—171′	1·86′	2·13 „
179′—184′	4·66′	1·37 „

The results of these borings confirm those previously obtained, showing that generally speaking the ores of Singbhum are of low grade, and on the whole just below what is likely to be payable, except when working on very large quantities of ore. A thickness of 16·80 feet, averaging 2·65 per cent. copper found at Laukisra, should, however, lead to the further testing of this occurrence by private enterprise. The 3-inch layer of ore giving 12·81 per cent. copper found at 736 feet in the Matigara hole is also of considerable interest, because this band happens to be identical in its mineral peculiarities with a persistent band of chalcopyrite, with blebs of quartz, ranging from 6 inches to 2 feet in thickness and found in the Matigara mine at a depth of 228 feet. It may so happen that at the depth of 736 feet the drill passed through a very thin portion of this characteristic band of ore, which is typically very variable in thickness. The encouraging feature is that this hole indicates the persistence of this band of rich ore from the depth of 228 feet to that of 736 feet. The Geological Survey drills have been lent to the Cape Copper Company, which is now further testing the Matigara lodes.

Engineering Questions.

Central India and the United Provinces.

47. At the request of the Chief Engineer, United Provinces, and of the Consulting Engineer for Protective Works in Central India, Mr. LaTouche reported on the geological features of certain sites selected as suitable for reservoirs and canal heads. These include :—(1) Murwari, on the Ken river, in the Panna State, at the point where the river issues from the scarp of Upper Vindhyan sandstones and shales near the southern boundary of Bundelkhand; (2) Kota, on the Bairma river, a tributary of the Ken, at the foot of the same scarp further west; (3) Gangao, where the Ken river issues from a gorge in the Lower Vindhyan sandstones at the head of the plateau of northern Bundelkhand; (4) a weir site on the Ohen river near Karwi, in Vindhyan sandstones; (5) a canal head on the Paisuni river, also near Karwi, where it is proposed to build the dam on a band of Vindhyan limestone, which forms a bar across the river; and (6) a dam in course of construction at Pahari on the Dhasan river near Harpalpur, where the foundation consists of Bundelkhand gneiss traversed by dykes of basic rock.

Fire-clay.

Rajmahal Hills, Bengal.

48. While examining the china-clay deposits of the Rajmahal hills, Mr. Murray Stuart recorded notes regarding some deposits of excellent fire-clay in the Hura, Chuperbhita and Pachwara coalfields. The deposits are rather difficult of access at present and are not very large, being distributed through the fields in beds seldom exceeding six feet in thickness.

Glass-making Sands.

Rajmahal Hills, Bengal.

49. Mr. Murray Stuart was deputed to the Rajmahal hills in January to examine certain occurrences of sand reported to be suitable for glass-making, and his report is published as a separate paper in Records, Volume XXXVII, Part 2.

He concludes that the sand met with in this area is generally

unsuitable for the manufacture of any but the commonest kinds of bottles. Sands occur as—

(*a*) recent river-sands, and
(*b*) Damuda (Gondwana) sandstone.

The river sands, of which the Ganges sand is the purest and most free from iron, yield a dark-green glass, which is only suitable for the cheapest beer- and wine-bottles, and is too dark to be affected by the admixture of manganese with the raw materials before fusion.

The white Damuda sandstone yields a sand with a high percentage of silica, and is the one mentioned by Mr. J. G. Cumming, I.C.S., in his report on the Industrial position and prospects in Bengal in 1908 (page 28, paragraph 2). The sand obtained from this sandstone yields a glass which is only faintly coloured by iron; consequently, by the admixture of manganese with the raw materials before fusion, a colourless crystal glass can be obtained. The objection to the use of this sand for glass-manufacture lies in the fact that it contains a somewhat large quantity of kaolin which it is practically impossible to eradicate under working conditions. The result of this kaolin is that the glass contains small inclusions, about the size of a pin's head, of a white opaque substance which is practically pottery; this of course renders the sand of little value for glass-manufacture, as no increase in temperature will affect the inclusions.

Gypsum.

Hamirpur District, United Provinces.

50. Information having been received from the Collector of Hamirpur District in the United Provinces that deposits of gypsum had been found at several places near the Biarma river, a tributary of the Betwa, Mr. LaTouche was deputed to examine them, as it was thought that, if the deposits formed a continuous bed, such as their reported mode of occurrence seemed to imply, they might possibly be of Lower Tertiary age, and afford a clue to the presence of Tertiary strata along the southern edge of the Gangetic basin beneath the alluvium. The examination of the beds, however, disclosed the following facts:—

(1) That the gypsum, in the form of crystals of selenite, is entirely confined to the older alluvium in the neighbourhood of the rivers and that it is of recent origin.

(2) That the crystals are found at certain definite spots at a depth of from 4 to 6 feet over very limited areas, the largest of which, near the village of Puraini, measured about 600 square yards, and that the mineral does not form a continuous bed or layer, being very limited in quantity.

(3) That the selenite crystals appear to have been deposited in a plastic clay occurring at these spots by water percolating from below, holding sulphate of lime in solution, and evaporating before reaching the surface.

Iron-ore.

Chota Nagpur.

51. Whilst working in the Singbhum copper area Mr. Fermor took the opportunity to examine various deposits of iron-ore being developed by the Bengal Iron & Steel Co. for their smelting works at Kulti.

These may be divided into two groups—the Turamdih deposits, some 4 miles from Kalimati, Bengal Nagpur Railway; and the Hakigora deposits, some 8 miles from Kalimati, and separated from Turamdih by a high intervening range of hills, which may be called the Dhoba Hills; this is composed of quartzites, slates, and phyllites of Dharwar age, which is also the age of the rocks with which both groups of iron-ores are associated.

The Turamdih deposits occur in some foot-hills at the north base of the Dhoba Hills in the villages of Talsa, Turamdih, and Kudada. The ore is magnetite; it is found in a series of schistose magnesian rocks, which have not yet been closely studied, but which contain steatite, as an important constituent. The magnetite occurs in the magnesian schists in four ways:—

(1) as scattered granules;
(2) as large patches of irregular shape;
(3) as definite veins traversing the magnesian rocks in any direction;
(4) as veins up to 3 feet thick, composed of magnetite, with vein quartz, secondary limonite and chert.

The magnetite is probably the result of segregation from the igneous rocks from which the magnesian rocks have doubtless been derived. At the surface the magnesian schists have been much

weathered, with the liberation from its matrix of a large quantity of magnetite in the form of granules and small lumps. These are recovered by sifting and picking by women and children, and form the chief portion of the ore won here. A certain quantity is, however, obtained *in situ*, by following up the thicker veins in open excavations.

The Hakigora ores occur in some small hills to the south of the Dhoba range. They consist of the banded magnetite and hematite quartzites so typical of the Dharwars in many parts of India. As at Turamdih the chief source of the ore is a detrital deposit formed by the breaking down of these ferruginous quartzites, in the course of which the layers of iron-ore are to a certain extent separated from those of quartzite. A small quantity of ore is also won by working the rock *in situ*, wherever there happen to be bands of iron-ore of sufficient thickness.

Manganese.

52. During the year Mr. Fermor completed his monograph on the Manganese-ore Deposits of India, issued as Volume XXXVII of the *Memoirs*. The chief results, briefly mentioned in previous Reports, are now brought together in a form that will be of great practical value to those engaged in manganese mining; but the work is equally important as a contribution to the purely scientific questions connected with the ore-deposits and associated rocks. From every point of view this memoir supersedes anything hitherto published on manganese-ores, and will take a prominent place in geological literature.

Singbhum, Bengal.

53. In January, 1908, Mr. Fermor visited two deposits of manganese-ore discovered since his previous visit to this district (in 1905). One of these—Tutugutu, near Chaibasa—is exactly like those previously examined in this area. The other is Leda Hill, which rises to a height of about 1,000 feet above the plains level near Goilkora, Bengal-Nagpur Railway. It is the only example in the district of a manganese-ore deposit occupying the top of a hill. But like the deposits of the Chaibasa area, this deposit has been formed by the superficial replacement of Dharwar slates, phyllites, and quartzites. The quantity of merchantable ore is small.

Central Provinces.

54. In November, during a visit of inspection to some of the manganese mines of the Central Provinces, Mr. Fermor obtained at the Gowari Warhona deposit in the Chhindwara district an important piece of evidence bearing on the age of the manganese-ores. Now that this mine has become deeper it is found that the manganese-ore band, which at the surface was fairly continuous, is much broken up by pegmatitic intrusions. These are seen abruptly truncating the beds of manganese-ore; and in one place a thin vein of pegmatitic rock was seen traversing the manganese-ore beds, and containing a small isolated inclusion of high-grade manganese-ore identical in physical appearance with the ore on either side of the vein. From this it is evident that the high-grade manganese-ore of this part of the mine was in existence at the time of intrusion of the pegmatitic rocks; the date of the latter is to be regarded as Archæan in the absence of evidence to the contrary; and hence it seems fairly certain that a portion at least of the manganese-ore of the Central Provinces was in existence in Archæan times, so that the present position of the deposits can have no genetic relation to the surface of the ground, and therefore the deposits may be expected to continue to depths that have no relation to the level of ground water, *i.e.*, possibly to very considerable depths. The deductions drawn from this occurrence at Gowari Warhona agree with certain evidences of intrusion of pegmatitic rocks into manganese-ores obtained at other desposits in the Central Provinces.

Gangpur State.

55. In December, Mr. Fermor visited some manganese-ore deposits opened up during the year in Gangpur State in Bengal. These are of considerable interest, because the ores contain braunite, and are associated with spessartite and rhodonite. In fact the occurrences resemble in every way the deposits typical of the Central Provinces rather than the superficial deposits of Singbhum, the only other part of Bengal in which manganese-ore deposits of any note have been located. The discovery of the gondite series in Gangpur is of considerable interest, since it means that this series has now been found at intervals over a belt, aligned roughly east and west for a distance of 700 miles, extending from Jhabua and Narukot on the west, through the Nagpur-Balaghat area of the Central Provinces, to Gangpur State in Bengal on the east. The gap

between the western exposures and the Central Provinces is largely occupied by the Deccan Trap formation; but in Chhatisgarh, occupying the gap between the Balaghat district and Gangpur, there are several areas of Archæan rocks, and consequently it will not be surprising if future prospecting leads to the location in this area of manganese-ore deposits associated with gonditic rocks. The Gariajhor deposit in Gangpur seems to be of considerable value, the ore being first-grade; owing to the small lead to the sea-board as compared with the Central Provinces, it will be possible to export ore at a profit from this deposit at times when most of the mines of the Central Provinces are closed down.

Inspection of mines, Central Provinces.

56. While on duty at Nagpur in connection with the Central Provinces and Berar Exhibition in November and December, 1908, Mr. Fermor was also deputed to make a third inspection of the manganese quarries. During this tour the following deposits were visited:—

Chhindwara District.—Gowari Warhona, worked by the Indian Manganese Company, Limited.

Nagpur District.—Mansar and Kandri, worked by the Central Provinces Prospecting Syndicate, Limited; Kacharwahi and Pali, worked by the Central India Mining Company, Limited.

Bhandara District.—Chikhla, worked by the Central Provinces Prospecting Syndicate, Limited; Kosumbah and Sukli, worked by the Central India Mining Company, Limited.

Balaghat District.—Thirori, worked by Mr. D. Laxminarayan.

As in all his previous work on the manganese-ore deposits of the Central Provinces, Mr. Fermor received the friendly assistance of the managers, and his report has been submitted to the Central Provinces Administration for communication to the Companies concerned.

As a result of his investigation Mr. Fermor is satisfied that there is now a general desire throughout the manganese area to work the deposits on sound principles, and in many cases considerable expenditure has been incurred in developing deposits by improved methods.

The point on which the future of the manganese industry of the Central Provinces turns is whether or no the manganese-ore

deposits continue of workable quality to any depth below the surface, or whether they are purely superficial in their mode of occurrence. Judging from the evidence discussed on page 43, it will be seen that some of the deposits probably continue to considerable depths. But this question cannot be settled satisfactorily until some of the typical deposits are tested by boring. When, in any given case, a company wishes to plan out the underground working of a deposit it will be wise first to test the deposit by boring to as great a depth as it is proposed to work it.

Petroleum.

Burma.

57. The Burma Oil-fields party for the season 1907-08 consisted of Messrs. E. H. Pascoe, G. de P. Cotter and Sub-Assistant S. Sethu Rama Rau.

Mr. E. H. Pascoe.

58. The first three months, up to the third week in January, were spent by Mr. Pascoe on the Yenangyaung Oil-field. Part of this period was spent in office work and in the consideration of the numerous points connected with the proper development of those portions of the field known as the Twingôn and Bémé Reserves. The rest of the time was taken up with the completion of the geological map of the Pegu inlier enclosing the oil-field. The anticline, on its flanks, is studded with small dip-faults, which, though unimportant in size, are interesting as indicating the direction of strain at the time the post-Irrawadi sandstone fold was produced. The direction of the anticlinal axis is 28° W. of N. to 28° E. of S., whilst the general average direction of these faults is north-east to south-west. Besides these flank faults, which are usually observed crossing and displacing the boundary bed between the Pegu beds and the Irrawadi sandstone, there are numbers of minute faults or slips having no constant system of orientation, in the more central area including the crest. Some of them may very possibly account for some of the anomalies in the petroliferous horizons. Around and south of Bémé mud veins take the place of these faults and in some cases are actually widened and plugged faults: they probably represent some former outflow of mud in the form of "mud volcanoes," which have since been entirely removed.

February was spent in the Lower Chindwin District, examining the numerous oil indications west of Kani and Kin. Small quantities of oil have been obtained by Burmans by digging pits, and these as well as natural seepages, occur on or near the crest of an anticline similar in structure to that of Yenangyat, having steep or vertical dips on its eastern, and comparatively gentle ones on its western flank. The rocks consist largely of hard impure limestone or calcareous sandstone, and conglomerate with limestone pebbles. The impervious nature and consequent small liquid-retaining capacity of the strata, as well as the dense and often impenetrable jungle clothing the hills, render prospecting hazardous and unpromising. The petroliferous rocks are presumably of Pegu age, as they are succeeded eastwards by fossil-wood-bearing, soft sands of the ordinary Irrawadi sandstone type.

The rest of the season was spent on the volcano, Mount Popa, in the Myingyan district. The bulk of the volcanic material is evidently post-Irrawadi sandstone in age, but a thin bed of ash and tuff intercalated among the latter sediments shews that activity commenced before the end of that period. The volcanic deposits consist mostly of conglomerates, tuffs, ash and andesitic lava flows.

Mr. G. de P. Cotter.

59. After initiating Mr. Sethu Rama Rau into his work at Singu, Mr. Cotter commenced at the end of November an examination of the southern portion of the Gwegyo Hills in the Myingyan district, and early in December continued his survey southwards along the same fold, including the Payagyigon-Ngashandaung Oil-field. The results of this work have already been published (*Rec., Geol. Surv., Ind.*, Vol. XXXVII, pt 3). In February Mr. Cotter removed to the Pakokku district. The hills north of Myaing village were found to consist of igneous rock, and an examination of the country around the oil seepages near Kyaukwet and Seewin shewed that the area was one of great faulting and contortion. In the latter region there is no simple anticlinal structure and the prospects of obtaining oil in any quantity are problematical. One point of some interest was the occurrence here of fossil-wood and marine fossils (*Pecten*, *Turritella*, etc.) in the same conglomerate.

With the exception of a brief visit, at the request of the Burma Government, to the Taungu stone quarries, the rest of the season was spent on the northern part of the Yenangyat Oil-field. The results of the latter will very shortly be published.

60. With the exception of about two months around Yenangyat and a brief visit to Thayetmyo, this season was spent on the Singu Oil-field, mapping the various fossil bands in the Pegu series. Some of these were traceable for a considerable distance, and could be recognised on both sides of the anticlinal crest. The fossil bands mapped were sufficient to demonstrate nicely the structure of this portion of the fold, and should be of some assistance in drawing the boundaries of the oil pools in the separate sands. Among the fossiliferous bands is one noticed by Grimes as the basal bed of Noetling's Yenangyaungian stage, consisting of a fissile clay containing sandy nodules, in each of which is found a cast of a fossil, usually *Tellina* or *Cardium*: these nodules recall forcibly the "box-stones" of the English Red Crag. Another easily recognisable horizon, low down in the series, is characterised by abundance of the coral *Dendrophyllia macroriana*: this horizon was also identified at Yenangyat. Several specimens of *Batissa kodaungensis* were found along the Pegu-Irrawadi boundary bed in block 28, Yenangyat. In block 31, Yenangyat, many specimens of a *Melania* were found in the red boundary bed. Two or three dip-faults were traced in the Singu field, the most conspicuous running through blocks 55° N. and 56° N. The boundary also between the Pegu and Irrawadi series (both in Singu and Yenangyat) is described as a strike fault.

M. R. Ry. S. Sethu Rama Rau.

61. Mr. Cotter has published an account of his observations on the Tertiary strata in the Taungtha hills in the Myingyan District. He finds the structure of these hills to be that of an asymmetric saddle-shaped anticline, or a single fold comprising two united elliptical domes, the direction of the axis being 30° west of north. Faults occur, but the most interesting point observed was the nature of the asymmetry of the anticline. Contrary to the usual condition, it is the dips on the west of the crest which are steep, while those on the east are gentle.

Results published.

Taungtha Hills.

The hills consist of Pegu beds as shown by fossils and the occurrence of selenite. The rocks have been subjected to considerable pressure, and Mr. Cotter concludes that the prospects of obtaining oil in this area are poor, owing to contortion and faulting (*Rec., Geol. Surv., Ind.*, Vol. XXXVI, pt. 3, p. 149).

62. Mr. Cotter has also summarised his work on the southern part of the Gwegyo hills, including the Payagyigon-Ngashandaung Oil-field (*Rec., Geol. Surv., Ind.*, Vol. XXXVII, pt. 3).

Gwegyo Hills.

The field-work was undertaken in December 1907 and January 1908 in order to obtain some idea of the prospects of oil-prospecting at this end of the Gwegyo anticline. The most characteristic feature in the Pegu beds is the great predominance of soft shale over sandstone, and the consequent flatness of the country. The thickness of Pegu rocks exposed near Nyaungnigyin is perhaps over 4,000 feet, and the junction of these beds with the Irrawadi sandstone on the east is a faulted one. In the Payagyigon-Ngashandaung area the eastern junction is faulted in an exactly similar manner, and the western junction is probably an unconformable one: the fault, as in the northern part of the anticline, appears to have occurred along or very close to the crest. Numerous fossils, including two species of nautilus, were found in this southern area, and the evidence points to a marine origin for these beds. Oil has been obtained here, but the prospects of obtaining it in paying quantities are poor. A remnant of the crest of the fold exists in block 5, but the anticline is pitching southwards.

63. My services were placed at the disposal of the Government of Burma from the 1st September to preside over a Committee appointed to investigate the present conditions of exploiting the Twingôn and Bémé Reserves in the Yenangyaung Oil-field, to examine the alleged dangers arising from flooding, fire and wasteful methods of working, and to make proposals for the better government of the field.

The Twinza Reserves.

After examining the information obtainable from the companies' agents at Rangoon, the Committee proceeded to Yenangyaung and collected information on the ground.

The reserved areas of Twingôn and Bémé cover jointly an area of about 450 acres, lying about ¼ mile apart, and separated from each other by the Khodaung block which is leased to the Burma Oil Company. The surface area of both Reserves is intersected by deep ravines, many of them having precipitous sides. The Twingôn Reserve having proved to be, by far, the richer in oil, has been most thoroughly exploited, and it is in this area only that the close drilling and dovetailing of independent companies

with the Twinzas (still working with the primitive system of hand-dug wells) is distinctly marked; it is consequently in this area only that the dangers feared are imminent, especially in the central part of the Reserve known as the Aungban. At the time of the Committee's visit there were 145 drilled wells in this Reserve together with 333 Burmese hand-dug wells, and of the drilled wells 76 were concentrated on an area of only 46 acres in the Aungban. In this section of the Reserve sites of only 60 feet square were valued and sold at prices often exceeding Rs. 40,000.

The Committee were convinced, as the result of examining the history of numerous wells, that those in close proximity often drain the same oil-sand below, and consequently affect one another in production. The sand-banks in which the oil is stored appeared, however, to be so irregular in shape that no constant rule could be laid down for the way in which the adjoining wells affect one another's supplies of oil; but it was evident that cases of mutual interference were sufficiently numerous to impress the companies with the desirability of rapid drilling in competition with their neighbours; consequently hasty drilling incurred dangers of fire, and (by the imperfect shutting off of oil-sands) danger of water penetrating and interfering with the productive capacity of the oil-sands.

As regards the dangers of fire the Committee noticed that no attempts were made to provide lightning conductors for the tall wooden derricks, and no guy-ropes were provided to pull the derricks over in any safe direction during fire. The oil in the receiving tanks near each derrick was measured by the use of a dip-rod inserted through a hole in the cover of the tanks, and the measurements being made by uneducated subordinates, who were only partially aware of the dangers involved, considerable risk was incurred by the use of naked lamps at night. Forges for dressing bits and boilers for driving the pumping and drilling engines were scattered indiscriminately among the wells, and were a source of constant danger in consequence of the frequent incoming of new spouting wells. The hand-dug Burmese wells were distributed irregularly among the drilled wells and were worked by people who are habitual smokers under conditions that would lead to a serious loss of life in case of any widely-spread fire. Casual strangers and pedestrians ignorant of the dangers around them were allowed free access to the congested part of the field. No

provision had been made for the cutting off of flowing wells during fires, and the whole area was covered naturally with a network of oil and gas pipes. Although the drillers were generally fairly cognisant of the dangers around them, and a general understanding had been established as to the precautions that ought to be observed, it was evident that in a field, already congested and likely still more to be developed with sharp competition, there was urgent necessity for detailed and exact regulations.

It had been alleged that, in consequence of the rapid exploitation of the oil, there was a tendency for the sands to become clogged by paraffin, with a consequent reduction in the total quantity of oil obtainable by drilling; but the Committee found that the deposition of paraffin could not in any way reduce the amount of oil finally extracted from the field.

A number of schemes were discussed for the resettlement of holdings in order to divide the interests into sufficiently large areas to prevent the ill-effects of competition and consequent hasty drilling. They found, however, in consequence of the objections raised by the companies themselves and the difficulty of treating the *Twinzayos* equitably, that the present system of ownership could not be disturbed, and that it was possible only to take steps to regulate the work of oil-winning in the Reserves. They consequently drew up a series of proposals for enforcement through a new Regulation. They suggested the appointment of a Warden for the field, who would have the powers and duties of a first-class magistrate, and they suggested that he should be assisted by an Advisory Board composed of one officer of the Geological Survey together with two members nominated by the Oil Companies themselves. They made proposals for the allotment of new sites and for the distribution of those sites which had been resumed by Government in consequence of breaches of the conditions under which they were originally allotted. They also formulated rules for the control of operations whilst drilling through water-bearing sands, and for governing surface operations likely to incur danger from fires. Proposals were also made for revising the form of grant in order to make it consistent with the new regulations. The companies having unanimously agreed provisionally to accept the proposed regulations, steps are now being taken to put the proposals into law by the Burma Government.

64. At the request of the Punjab Government, M. Daru while in the Mianwali district studying the alum shales, also visited the oil-springs at Jaba in the same district. The total monthly output from ten springs is about 50 gallons only of thick, dark-green, sulphuretted oil. He found the strata to be so disturbed that he doubted the feasibility of obtaining larger supplies.

Punjab.

Salt.

65. In the General Report for 1907 (*Records*, Vol. XXXVII, p. 37) reference was made to the theory which I had offered to account for the origin of the salt accumulations in the Rajputana desert. Dr. W. A. K. Christie having designed the apparatus required to sample the desert winds and having made a series of preliminary tests under Laboratory conditions, volunteered to undertake the work in the desert during the hot weather of 1908. He set up his apparatus near Pachbadra (25° 55′ N.; 72° 11′ E.) in April and carried on daily observations until early in June when Sub-Assistant Vinayak Rao carried on the field work alone. Both officers deserve the greatest praise for the way in which they cheerfully faced the hardships of camp life in the desert during the hottest part of the year.

Rajputana.

Observations were made throughout each day regarding the speed of the wind and the atmospheric temperature and pressure. Samples were collected at regular intervals until the burst of the monsoon in July, and these, with samples of sand and rain, were afterwards investigated by Dr. Christie at headquarters. A joint paper will shortly be issued by Dr. Christie and myself detailing the results of this interesting enquiry, and the following are our chief conclusions :—

It has now been shown by actual observation during the hot weather that large quantities of sodium chloride in the form of fine, dry dust are carried into the desert region of Rajputana from the south-south-west. Concluding from the daily observations made at Pachbadra during the hot weather of 1908, the amount of salt passing a front 300 km. broad and 100 m. high during the four hot-weather months might be indicated as 130,000 tons. The hot weather of 1908 was a season of unusually weak winds, and this figure (which has little more than qualitative value) is probably well below the annual average influx of salt dust.

When it is known that these hot winds blow steadily towards the north-north-east for three or four months every year, that they are strongest (often attaining

the speed of gales), during the day-time when the salt dust is dried by the scorching sun under a cloudless sky, that there is no reflux and very little variation in direction, with a gradually diminishing speed as the heart of the desert is approached, and that the period of hot, dry, southerly winds is followed always by a downpour of rain, with the formation of a lake in each small area of internal drainage in the Rajputana desert, it is easy to account for the great accumulations of saline silt which are left after the annual desiccation of the salt lakes.

These winds from the south-south-west blow over the arm of the sea known as the Ran of Cutch, which is covered with a layer of white salt during the hot, dry season. Every disturbance of this crust by pedestrians and animals helps to form the salt dust which is wafted away towards Rajputana. The winds blow strongly in the day-time, with a lull at nights, but the movement is all in one direction at the time of year when the dust is dry and can be carried most easily; and there is no set-back until after the monsoon period of rain, when all the finely-divided salt dust that may have reached the heart of the desert is washed into the hollows occupied by brine lakes. The strength of these winds is indicated by the fact that small foraminifera have been carried bodily (not rolled) as far as 500 miles inland from the coast of Cutch.

An idea of the quantities of salt to be accounted for is given by a special examination of the Sambhar Lake: the silt of this lake partly fills a depression in the Aravalli schist "country;" it has been shown by two borings that the silt is about 70 feet thick in places, and, as the result of detailed sampling at regular intervals, it has been shown that the uppermost 12 feet of this silt over an area of 68 square miles includes 55,000,000 tons of sodium chloride. There are many other smaller salt lakes of the Sambhar type on the Rajputana highlands, and there may be many such bodies of silt buried under the mantle of sand.

We consider that the action of the wind alone is sufficient to account for the large accumulations of salt in Rajputana. The instance is one of special importance from the circumstance that on the Rajputana highlands no other explanation offered will account for any but unimportant quantities of salt; there are no inflowing large rivers; there are no traces of ancient rock-salt deposits; no known saline springs; no likelihood of subterranean water rising to the surface; no probable connection throughout most of the areas lying on the crystalline schists with the water which is possibly percolating underground from the lower-lying Punjab plains towards the still lower depression of the Indus valley.

While admitting that rock-salt deposits may be formed in other ways also, our observations in Rajputana go far to strengthen the evidences gathered by the late J. Lomas and others to show that many rock-salt deposits, like those in the British Trias, are dependent on desert conditions. Large desert areas are regions of indraught during the hot, dry seasons, when any salt available is easily pulverised. Where these are regions of internal drainage, the salt becomes "fixed" in local hollows after rain; in the Rajputana salt-lake region we find deposits of gypsum, nodular limestone, and plano-convex, lenticular masses of calcareous mud stained black with ferrous sulphide, which, on oxidation, would give rise to the red colour so characteristic of the marls and sands associated with rock-salt deposits.

The well-known estimates of the age of the ocean made by Professor J. Joly included a ten-per-cent. correction due to the sea-salt carried inland by winds and brought down by rain to add to the quantity carried to the ocean by rivers.

References to the salt carried inland by sea-breezes have generally assumed that the principal quantities leave the ocean as fine spray ; but it appears from our observations that, under special conditions like those in Western India, where a desert region forms the hinterland of a salt-incrusted temporary arm of the sea, far larger quantities of sea-salt may be carried inland as finely divided dust. It is impossible, however, to say from our results that Professor Joly's allowance for sea-salt in river waters should be materially increased. The process by which the salt is formed in the Ran of Cutch tends to eliminate the rarer and more soluble magnesium and potassium salts, leaving the wind-borne chloride to be more purely that of sodium than would be the result of an inland transportation of simple sea-spray. The iodine and bromine in the Sambhar brines are found to be in a smaller ratio to the chlorine than in sea-water, possibly for a similar reason, but these two halogens bear in Sambhar just the same ratio to one another as they do in the sea.

Tin.

Geology: Mergui Archipelago.

66. Mr. Page continued his survey of the Mergui district, devoting the first quarter of the year to an examination of the archipelago. In these islands granite forms the prevailing rock-feature, and it occurs both in the gneissoid form, apparently similar to the usual Archæan gneiss, and in a distinctly intrusive form, the latter penetrating both the older granitoid gneisses and the sedimentaries.

Granites.

The islands in which granite was observed may be divided into six groups :—

(1) The western group, consisting of Moscos, Metcalfe, Great Western, Torres, Hayes, Fletcher and Clara. All the intermediate parts of this outer group are also probably granitic. Both kinds of granite were observed in this group.

(2) An ill-defined group comprising the western part of Elphinstone, south-east Elphinstone, Grant, the northern half of Ross, Maingay's and smaller islands as far east as Cantor. The larger portion is of gneissose granite, into which the younger granites and numerous quartz porphyry dykes have penetrated.

(3) A large domed outcrop, a little south of King's Island Sound, all the south of King's, Mergui, Sellore, Tucker, Julian, and the central ranges of Kissering. In this group gneissose granites predominate.

(4) Parker and Domel down to and including High Island form another series of basal granites; they may be traced north through the Pickwick group into Cantor and south through the Gregories and down the coast to Victoria Point and the adjacent islands.

(5) Davies Island is apparently an isolated granite outcrop, but extremely bad weather prevented the adjacent islands being carefully examined, and there may be granites in the interior of St. Matthew's.

(6) Koolagyun, and the low islands mostly covered by swamp, which extend for miles down the coast, are composed of granite, usually of the basal variety with intrusive granites and pegmatite veins penetrating them in all directions.

Quartz-porphyries form a very important factor in group 2. They occur intrusive into granites and the sedimentaries. Mount Elphinstone (west coast Elphinstone Islands), the peak on Maingay's, and Cantor are all examples of intrusion into granites; and Hayes, Julia, the extreme south of Cantor and some islands east of Ross show examples of intrusions into slates. Johnny, Paton, Allan and other islands near are composed for the most part, if not entirely, of quartz-porphyries.

Mergui series.

67. Above the granitic rocks there is a series of indurated sandstones, quartzites, slates and schists. These rocks are as a rule much crushed, at times sparsely mineralised, and generally do not cover any considerable area. They are usually met with in small mountain streams. Above these comes a series of slates, sandstones, grits and conglomerates. But they are not always all present, denudation having generally removed the last-mentioned rocks. As far as is known Pataw is the only island formed of conglomerate. The series may be observed in the following groups of islands: Central Kings, some 7 miles from the east coast line, Iron, the north-east of Maingay's island and the adjacent islands, central and north-east Elphinstone, Macleod's, Southern Ross and adjacent islands, the Warden, Christmas, Bentinck, the Five Sisters, St. Luke's, St. Matthew's in parts, Bushby, Father and Son, Lord Loughborough, and Governor Swinton and Cavern are all of sandstone and belong to the lower part of the Mergui series. Hayes,

Julia, Cantor (south end) and Sullivan are all slate islands, and may be classed with the above.

In connection with the above sedimentaries, there is a series of sandstones, slates, and breccia-conglomerates which at times exhibit a schistose character, and are difficult to connect with the lower part of the series. They dip irregularly and show the effects of the intrusive granites to a much more marked extent than the older group. These formations may be seen in islands near and north of Governor Swinton, the small islands south-west of Bentinck, some of the Marien group, islands south-west of Sir William James Islands and in a series of reefs along the east coast of St. Matthew's. In this last case, there are granite boulders, some as much as six feet long, well water-worn, and resting irregularly in a matrix of limestone sands, forming a granite-limestone conglomerate. Subsequent upheaval has given the whole a much crumpled and schistose appearance.

Similar deposits were met with in the Tavoy district in the Hindu and Gt. Tenasserim rivers; and there are somewhat similar occurrences in the vicinity of the Tavoy river.

Moulmein Group.

68. No rocks were discovered that could be safely attributed to this group. The limestones forming the Elephant group and also those on the south-east of St. Matthew's Islands being probably older than the adjacent slates and conglomerates. They are very crystalline and apparently unfossiliferous.

Recent deposits.

69. There still remain three younger deposits which cannot be classed as one, and yet are probably of about the same age. Between them they cover quite a considerable area of the low flat islands, mentioned in group 6 of the granites, and also some of the islands on the south, the swamps and parts of the mainland. They are laterite, a partly cemented boulder-breccia and lithomarge.

They are all shallow, the laterite being seldom thicker than 14 feet, the conglomerates even less, and the lithomarge seldom over 60 feet. They all appear near granite and overlie them and the adjacent slates, schists, etc., of the older Mergui series.

The laterites and the conglomerates are often found associated, as also the laterites and the lithomarges in the more southern parts of the archipelago.

The laterites on Koolagyun and some of the adjacent islands are sufficiently rich in iron to be used as an ore.

The conglomerates when near water often present a deceptive lateritic appearance. In Tavoy district the cementing material of the conglomerate often carries a little gold.

The lithomarges in the vicinity of Yengan-Bokpyin often cover workable tin-bearing gravels, and were probably derived from the older slates, schists, and some of the felspar of the granites; the mottled appearance (red to blue) being due to the oxidation of iron derived from the dark mica, the tourmaline and the magnetite of the granites. The islands of Pumpkin, Pig, the Gregories, Carnac, Collins, Jenkins, etc., all furnish examples of these three younger deposits.

Geological disturbance.

70. Split, crushed and otherwise disturbed rocks, which indicate pressure applied in an east and west direction, are abundantly evident. Nearly all the small islands, composed of sandstones, show their strata up on end, and only in the larger islands, *e.g.*, Bentinck, are dips as low as 30° found. The slates are nearly always crushed and penetrated by quartz veins, and in the case of Hayes Islands there are two distinct folds roughly at right angles to one another. Owing to the numerous granite and quartz-porphyry intrusions, it is rather difficult to delineate the principal lines of disturbance through the district, as separate from purely local disturbances.

Cassiterite.

71. Cassiterite is found in gravels on King's, Kissering and Davies Islands. On the first-named it has been worked. Kissering is the best of the three and is worth prospecting, the cassiterite occurring within six feet of the surface. The tin on Davies Island to judge by the places tested in the stream which enters the sea near the south-east corner of the island, would not pay to work. All the granite of sub-group 2 is worth prospecting for cassiterite. Although quartz lodes were frequently found, none carried visible minerals of economic value.

Gold.

72. Gold is found on Horsborough Island and has been worked. It occurs as small flakes in gravels at comparatively shallow depths. On Russel Island there is a series of pyritic veins a little above sea-level which yield 10 dwts. gold on assay. These veins are crossed by several quartz stringers.

Lead and Iron.

73. The only galena met with was on the west coast of Maingay's Island and this has already been reported on. Various laterites would furnish a certain amount of iron-ore were there a local demand.

Tavoy district.

74. At the end of March Mr. Page proceeded to the Tavoy district. In this district tin-mining was found to be at a standstill.

The following localities in which stream washing is carried on during the monsoons were visited:—

(*a*) Maungmeshaung river.
(*b*) Ongbingwin.
(*c*) The Hindu river and its tributary streams, including the Hinda river.
(*d*) Old workings in the vicinity of the granites near Wagon, and about the village of Pagayè.

The results of investigation hold out no great hopes of the future of a tin industry in this district.

The following is a more detailed description of these localities.

(*a*) *Maungmeshaung.*—In this area washing is carried on also by the most primitive methods. Even ground sluicing is apparently unknown to the villagers engaged. The cassiterite is derived from the granites as well as from quartz veins at the slate-granite junction. Boulders of each of these rocks carrying cassiterite are to be found in the stream. Apparently two concentrations have taken place, one in which the cassiterite was concentrated on a thin clay layer on the denuded slates, whence they were washed by the present stream. The gravels are irregular, and the concentrated cassiterite will only pay to wash at intervals. European prospectors will find it more profitable to search for lodes in this locality than to work the gravels.

Wolfram is associated with the cassiterite, and occurs in rather large irregular segregations and thin veins in larger quartz veins in the slates.

(*b*) *Ongbingwin.*—At this place the cassiterite occurs in quartz veins; the widest cassiterite-bearing vein found was only 12 inches thick. Cassiterite also occurs in small quartz stringers which have penetrated the sandstones near the

granites in directions which cause the sandstones to split in irregular rhomboidal masses. It is probable that most of the cassiterite found in the gravels about the base of the Kehdaung is derived from this source. For a long time to come cassiterite will be concentrated in the streams during the monsoon in quantities that will pay to work. Whether it would pay a company to attack the hill on a large scale is extremely doubtful.

The natives are only able to work the gravels down to about 6 feet, and from one or two who worked with European prospectors, provided with pumps, it was ascertained that the concentrate proper is some 30 feet below the present surface.

In this locality and along the east shore of the Heinza Basin, tin-stone, wolfram, and gold are found. The auriferous specimens collected have not yet been assayed.

(c) *The Hindu river and its tributaries* drain a portion of the central range east of Wagon. The Hindu enters the Khamaungthway, and the Hinda, the Bean river, each tributaries of the Great Tenasserim. Cassiterite, in quantities that should be payable, exists within a few feet of the surface, and in the valley of the Hindu, gold is found with the tin concentrate. The Golden stream is perhaps the richest known locality, but very little has been done in exploring to depths over 8 feet. The streams for 15 miles to the north of the Hindu carry gold, but in no case were values obtained that would appear to make it worth while to mine the gravels. From evidence obtained from boulders there is a strong probability of a quartz lode existing between the Hinda and Hindu. The boulders discovered carry tin in payable proportion, and indicate that the lode is at least 30 inches wide. This lode will cross streams which are already leased for lampan workings.

(d) At the base of the *granite hills near Wagon* and north of the road there are old workings, and in isolated patches cassiterite, sufficiently concentrated to be worth washing on a small scale, may be found. This locality is approximately south-south-east of the tin-workings on the Maungmeshaung stream. There is a possibility of lodes

being found, but pits will be necessary. At Pagayè there are tin-bearing gravels, which are, however, worked out. Some wolfram remains, and was traced to its source in quartz veins some 3 miles up the Sanchè stream, a tributary of the Pauk Tein. Here there is a series of almost vertical quartz reefs varying from 30 inches to an inch or two in thickness. Only one of some 50 veins carried wolfram, but this was very rich, the wolfram forming a very large percentage of the lode, which was 14 inches wide.

The quartz veins occur in slate of the Mergui series which is partly metamorphosed to schist. This locality gives promise of future success to the prospector.

Besides visiting the above localities a tour was made from the Tavoy river, in a general south-easterly direction to near Mount Myinmolet-kat and down the Bean river to Myitta. The structure of this region is much the same as that of the archipelago. There are numerous gravel areas which looked as if they might contain cassiterite, but testing them in stream cuttings even down to 14 feet proved unsuccessful.

In the month of November a tour was made across the country from the Tavoy to the coast and along the granite hills to the Heinza Basin. All the high land is granitic, and there are large flats covered by the disintegrated granite sands. Floods prevented panning in the streams, but from the general appearance of the country there should be gravels worth working as well as lode formations near the granites worth testing.

75. There is one geological feature prominent in the Myitta valley that is not met with in the archipelago, and that is a Tertiary deposit which can be traced almost 60 miles north and south, and is some 12 miles wide in parts.

Tertiary strata.

It consists of a series of shales, which dip generally at angles less than 18°. They strike roughly N. and S. and rest unconformably on the denuded older rocks, which form the flanking hills. These shales have numerous plant and fish remains not yet determined. On the shales rest conglomerates, which to a large extent have been derived from granites, and in many places the appearance of the arkose is so deceptive that it exactly simulates a granite. In some localities these conglomerates and

shales are interbedded. A sandstone bed is apparently associated with them, and fossil-wood has been discovered in the Ayu stream, a few miles north of Myitta.

GEOLOGICAL SURVEYS.

Baluchistan.

Dr. G. E. Pilgrim, M. R. Ry. Vinayak Rao.

76. Dr. G. E. Pilgrim was engaged during the field season 1907-08 in a survey of the Bugti and Marri country in Baluchistan, paying special attention to the Upper Tertiary fresh-water formations from which vertebrate and invertebrate fossils were obtained thirty years ago by Dr. W. T. Blanford and more recently by Major McConaghey, the latter collections being already described by Dr. Pilgrim in *Records*, Vol. XXXVI, part 1.

Dr. Blanford was compelled to limit his work in this area to a mere reconnaissance, and naturally his conclusions, published in *Memoirs*, Vol. XX, need a certain amount of revision after this more detailed examination of the ground, the most important changes being made in the Upper Tertiary fresh-water beds. Although in the northern portion of the area Dr. Blanford had recognised the existence of three distinct formations in the Upper Tertiary—Upper Nari, Lower Siwalik and Upper Siwalik —and had mapped them as far north as Dera Ghazi Khan, he did not recognise the Nari further south, and referred all the fossils there collected to the Lower Siwaliks.

Dr. Pilgrim, however, has found that the lowest 1,000 feet of the formation, mapped as Lower Siwalik in the Bugti Hills by Dr. Blanford, is Nari, and is separated from the Lower Siwaliks by a marked unconformity. In the Nari occur anthracotheroid remains, *Aceratherium blanfordi*, and the remarkable molluscan fauna described by Blanford, while the Lower Siwaliks have yielded *Dinotherium indicum*, *Mastodon angustidens* and *Mastodon pandionis*. Dr. Pilgrim has made from the Nari beds a large collection of bones and teeth, which he has partially examined and briefly described. Although the wealth of species is not great the fauna clearly indicates an Aquitanian age. With the *Rhinocerotidæ* anthracotheroids (and in especial the genus *Brachyodus*) dominate the fauna. Representatives of the genera *Dinotherium*, *Tetrabelodon*, *Macrotherium*, *Cephalgale*, *Amphicyon* and *Pterodon* occur.

Full descriptions of these will appear later. At the base of the series there occurs fairly constantly and over a wide area a band of marine rocks containing characteristic Nari nummulites. The marine beds pass gradually upwards, through estuarine strata containing mammalian bones and oysters, into true river deposits. Lithologically these beds are similar to the Naris of Sind, and especially to those exposed at Bhagathoro, near Sehwan. The greater coarseness of the sandstones and the abundance of ferruginous matter renders them readily distinguishable from the Lower Siwaliks.

There is a close lithological resemblance between the Lower Siwaliks of Sind and those of Baluchistan, the most typical beds being certain concretionary conglomerates with clay pellets, and there is no doubt that the fossiliferous horizons in the two areas are identical.

The occurrence of *Tetrabelodon angustidens* fixes an upper age limit for the Lower Siwaliks in the Sarmatian, while a consideration of their fauna, as compared on the one hand with the Nari and on the other with the Middle Siwaliks of the Potwar in the Punjab, inclines Dr. Pilgrim to think that they are most probably of Tortonian age.

The Middle Siwaliks were not found in the Bugti and Marri hills, the characteristic Upper Siwalik brown sands and clays, conglomerates and boulder beds resting unconformably either on the Lower Siwaliks or on the Nari.

77. Post-Tertiary deposits, differing but little in appearance from the Upper Siwaliks, but horizontally bedded and often resting unconformably on the latter, were seen in many places. Dr. Pilgrim considers that many of them, like the older portion of the Indus alluvium, are of Pleistocene age.

78. The division between the Lower Tertiary Kirthar and Laki series was recognised and marked on the map, which also covers a small area of the Cretaceous formations which, a little further north, have furnished the well-known Mazar Drik collections.

79. Dr. Pilgrim calls my attention to the excellent field-work done by Sub-Assistant M. Vinayak Rao, and his favourable report merely falls into line with the reports of all officers under whom Mr. Vinayak Rao has worked. He extended the survey as far north as Fort Munro and mapped large areas of Cretaceous, Laki and Kirthar rocks.

Burma.

80. The survey work done in Burma is described under the heads *Petroleum* and *Tin*, the work of Messrs. Pascoe, Cotter and Sethu Rama Rau being confined to the oil-bearing regions in Upper Burma and that of Mr. Page to the areas worked for tin in the Mergui and Tavoy districts. Mr. Pascoe was in charge of the work in Upper Burma, and reports on the high quality of the work done by Mr. Sethu Rama Rau.

Central India and Rajputana.

Messrs. C. S. Middlemiss, H. C. Jones, A. M. Heron.

81. In consequence of demands in other areas, the Central India and Rajputana field party during the working season 1907-08 underwent some changes in its personnel. Messrs. H. Walker and Sethu Rama Rau were diverted to other duties, Mr. Heron remained, and Mr. H. C. Jones joined the party for the first time. Mr. Middlemiss continued in charge of the operations, and was able personally to visit the area during the last two months of the working season.

Linking up with older work to north and north-west.

82. In the last General Report the hope was expressed that the then ensuing season would witness the linking up of the work with that completed many years ago to the north and north-west by Messrs. Hacket and Kishen Singh.[1] To a certain degree this has been realised: at several points the new survey has come into touch with the old one, so that the early months of the current season should see the junction complete. The junction is, however, a superficial and provisional one only; there still remains the difficult and delicate task of accommodation and revision along the boundary between the old and the new, and this may further necessitate revision of parts within the old surveyed tract, which has only been very generally described by Mr. Hacket (*loc. cit.*). In that paper, also the various sub-divisions of the Vindhyan system (including the Lower Vindhyan shales and the Kaimur, Rewah and Bhander series) are described as having been recognised, whilst the large-scale maps contemporaneously produced represent these same sub-divisions with the utmost nicety—although no convincing reasons are given for

[1] Mapped on the 1" = 1 mile scale and briefly reported on, *Rec., Geol. Surv. Ind.*, Vol. XIV, pt. 4, p. 279 (1881).

correlating them thus minutely with their supposed far-distant eastern equivalents, from which in fact their outcrops are separated by enormous areas of obliterating Deccan Trap and alluvium. With no fossils to guide and with discontinuous outcrops, the arbitrary splitting up of them in this western area to accord categorically with the divisions in the typical eastern area appears unwarranted, as it may also be very misleading.

The Central India party has already been compelled to make use of one tentative grouping of the Vindhyans in the neighbourhood of Bhopal, a grouping which has only with some reserve been proved to hold across the intervening area between it and the typical region; whilst for detached outlying masses separated from the main outcrops by many miles and buried in a sea of trap it was occasionally found necessary to be content with marking the outcrops simply as "Upper Vindhyan." In conformity with this caution, and from what has been already seen of these western representatives of the Vindhyans near Rampura and Neemuch, we are at present unprepared to accept without further enquiry the sub-divisions originally given them by Mr. Hacket.

Area surveyed.

83. The work done last season includes the completion of sheets 211 (already begun in the preceding season) and 210. Sheets 239, 240, 241, 271, 272 and 273 were also completed with the exception of the portions of Gwalior State within them. Sheets 177, 178, 208, 209, 238 and 270 were partially surveyed. The area embraces portions of Rutlam and Sailana, Banswara, Partabgarh, Jaora, Sitamau, Dewas and Indore.

Aravalli series.

84. The Aravalli series, already touched for the first time during the previous season, were again further explored along the westward margins of the Deccan Trap, but even this further acquaintance with them is not yet sufficient to warrant any generalisations of importance. A number of highly inclined bands of different rock types, all having a metamorphic or crystalline character and striking roughly north-north-west—south-south-east or north-west—south-east build up a sort of platform at the 900 feet level, on which the horizontal layers of Deccan Trap come to an end in their westward extension as fringing scarps or as detached outliers. In the Progress Reports sent in by Mr. Middlemiss and Mr. Heron much detailed information is given regarding the slates

phyllites, schistose conglomerates, mica-schists, quartzites, hornblende-schists, crystalline limestone bands and the curiously related limonite-quartzose or cherty bands with in some cases grünerite, mixed gneisses, granitic gneiss, porphyritic hornblende syenite-gneiss and acid pegmatites, etc., but with the exception of a provisional attempt to map some of the crystalline limestone and ferruginous cherty layers which build a set of rocky ridges following the usual strike, no endeavour has yet been made to separate the series as a whole according to age or mode of origin. Having only so far been seen in the bottoms of the valleys cut out among the trap plateau, or in the vicinity of its western margin, it seems premature to attempt any such comprehensive classification for the present. Among such difficult rocks it will be necessary to proceed slowly and with caution for some time to come. Nevertheless there is but little doubt that the rock series here called Aravalli represent the series of the same name as defined by Hacket, at least in the main; but whether any of the quartzites should be separately grouped with the much younger Alwar or Delhi series which along certain lines in the Aravalli range has been described by Hacket as caught up in folds among the older Aravalli schists, it is impossible to say. It is equally uncertain whether or not the mixed gneisses are the equivalents of those referred to as "gneiss" by Hacket and coloured separately by him on his maps. Mr. La Touche in his more recent survey of western Rajputana (*Mem., Geol. Surv. Ind.*, Vol. XXXV, pt. 1, p. 6) found the rocks west of the Aravalli range, marked "gneiss" by Hacket, to be granites of two distinct ages, namely, the Erinpura and Siwana granites, differing widely in texture and composition. It seems quite likely, from what has already been seen during the past season, that there may well be exposed in this region both ancient Archæan gneisses and later eruptive plutonic masses.

Delhi series.

85. Standing apart from the quartzites enfolded among the crystalline schists, and outcropping at much higher elevations among the Deccan Trap plateau to the east-north-east of Partabgarh town, occur a set of nearly horizontal quartzites or quartzitic sandstones and siliceous shales forming bare scarped hills. They represent one of the points of actual junction between the present and the old surveys, having been identified by Hacket and marked on his published map as the southernmost extension of his Delhi series,

The same rocks are stated by that author to be overlaid unconformably to the north beyond Neemuch by the shaly series which he marks as Lower Vindhyan. The former were examined by Mr. Middlemiss' party, but the question of their relation to Hacket's Lower Vindhyans was not then gone into, and remains one of those that must be taken up immediately for important stratigraphical reasons. The first of these reasons is connected with the general doubts which have already been alluded to concerning the strict applicability of the sub-divisional scheme adopted by Hacket for his Vindhyan system. The second reason is that two earlier observers, Medlicott and Mallet, each referred the so-called Delhi quartzites to the Vindhyan system in the first instance, although the former afterwards expressed himself as satisfied with Hacket's relegation of them to the much lower Delhi series (see *Rec., Geol. Surv. Ind.*, Vol. XV, Annual Report, p. 3). The impression now obtained of these strata is in favour of the earlier view, or at least that there is not sufficient difference between them and the Rampura scarp of Hacket's Kaimur to place them in separate systems. They are found to be not very strongly altered, the original rounded grains, the pebbles and other evidence of a sedimentary origin being quite appreciable to the naked eye. In some yellowish or pinkish siliceous shales locally becoming calcareous, which lie beneath the coarser quartzose rock, some very obscure leaf-like impressions were noted and some markings, including rows of pittings of very much the same nature as those described and figured by Mr. Vredenburg (*Rec., Geol. Surv. Ind.*, Vol. XXXVI, pt. 4, p. 241) from the Pab and Vindhyan sandstones of other localities. None of these shales show any mineralisation or foliation. Whatever be the final judgment as to the age of these beds, it is quite clear that they can have nothing in common with the phyllites and other schistose rocks found in the lower zone of so-called Aravallis as just described further west below the crest of the Deccan Trap plateau.

Quasi-organic remains.

86. The next point where this survey touched the old mapped area is near Kukresor and Rampura in northern Indore, where Hacket's and Kishen Singh's Lower Vindhyan (or Suket) shales and Kaimur quartzite scarp occur. These rocks were examined

Lower Vindhyan, or Suket Shales and Kaimur scarp (Hacket and Kishen Singh).

by Messrs. Middlemiss and Jones, and they exhibit the shales everywhere in conjunction with the Deccan Trap plateau to the south; so that it was impossible to know what came immediately below them. Mr. Jones has made a careful study of these two formations and filled in the gaps in the mapping left over by the earlier survey. His Progress Report is amply illustrated by photographs and drawings.

The shales may be concisely described as being much softer than those below the Delhi quartzite. They are also generally much more fissile, breaking up into little cakes, not into splinters. Their colours vary from a drab or buff on the lower slopes of the scarps to darker and sometimes chocolate, purple and green tints in the lower river-bed sections. They are so soft and fragile that one can hardly make a specimen of them. Glauconite-bearing bands occur high up under the quartzitic scarp, and harder, micaceous, flaggy beds and free-stones (much used for building purposes) occur at lower horizons, with some rare calcareous beds, showing 300 feet at least, the base not being attainable. They lie practically horizontally but with small, sudden warpings and puckerings. There are no traces of porcellanic beds (compact fine ash, see *Mem., Geol. Surv. Ind.*, Vol. XXXI, pt. 1, p. 93), which in the Son valley sections characterise the Lower Vindhyans, and there are also no important limestones to correspond with the Rhotas and other limestones of the typical Lower Vindhyan area.

Fossils.

87. It may well be that the survey of this area may best be signalised by the finding by Messrs. Middlemiss and Jones of some very minute organic bodies in these shales. Mr. Jones, who subsequently examined them more carefully in Calcutta, describes them as small concentrically wrinkled discs of carbonised chitinous substance, and he thinks it not impossible that they may represent the genus *Obolella* or *Chuaria circularis*, described by C. D. Walcott from Pre-Cambrian rocks of Arizona[1] or possibly the operculum of *Hyolithellus*.[2]

Quartzite scarp (Kaimur of Hacket)

88. The quartzite scarp which follows above these shales is a very striking formation, building a wall-like rampart, and stretching as far as the eye can see. It is a

[1] Bull. Geol. Soc. of America, Vol. X, p. 234 (1899).
[2] Bull. Geol. Soc. of U. S., Vol. IV, p. 141 (1886). with Pl. XIV, fig. 2c.

quartzite rather than a sandstone, not unlike some of the Delhi quartzite just described, but without being identical in any particular. It breaks with a roughly conchoidal fracture and may be trimmed into good rough blocks, suitable for building purposes, but it cannot be got out in slabs like the typical Kaimur.

Detached blocks.

89. A curious set of rather small outliers of this quartzite occurs generally some way south of the main scarp and at a much lower elevation, lying on the Suket shales not far from the Deccan Trap boundary. These outliers, according as they approach the Deccan Trap boundary more nearly, become of the nature of isolated crags or blocks arranged in clusters on the summit of gentle rises in the shales. An enormous number have been mapped by Kishen Singh, but many more would require delineation. Their most remarkable feature is their disturbed dips near the edge of the trap plain. The disturbance is not uniform. From block to block, separated perhaps only by a few feet, the dips vary widely in amount and direction. The whole at first sight presents an appearance of chaos. A number of these were plotted on a large scale by Messrs. Middlemiss and Jones.

Lametas.

90. Lametas were found at one place only by Mr. Heron on sheet 214, forming an irregular horizontal shelf, unconformable on the metamorphics. The bed is 10 feet thick and composed of impure, pale-purple limestone with grains and pebbles of quartz.

Deccan Trap, Intertrappeans, Laterite, etc.

91. The great spreads of Deccan Trap (with its occasional Intertrappeans and cappings of laterite) was naturally met with over very large areas surveyed during the season. Its characteristics remain much as before, and a number of separate studies of individual occurrences have been made and submitted in the reports by Messrs. Jones and Heron, with numerous sections and photographs in illustration of the chief facts. Intertrappeans were met with principally in parts of north-west Jhalawar and thin bands of clay were also noticed at a few places. Laterite occurs largely as cappings to small hills, principally in the States of Jhalawar, Rampura and Sitamau, with occasional masses of residual blocks and lateritic gravel. In some cases Mr. Jones has described rock dwellings cut out of the laterite, and rock temples,

such as the Dhamnar cave temples, where the laterite is about 60 feet thick.

Peculiar position of the trap.

92. With reference to remarks made in a previous General Report (*Rec., Geol. Surv. of Ind.*, Vol. XXXIII, pt. 2, p. 108) on the subject of the almost universal absence of recognisable outliers of trap on Vindhyans, it may also be noted that in the area surveyed last season the same peculiarities are equally prominent. It is almost impossible ever to find a denuded natural section cut out of trap and showing Vindhyans below. But the case is entirely different as regards the behaviour of the trap to the Aravallis. In this case the usual position at the margins is to find the former as outliers capping hills of steeply-dipping schists, or running out as a sheeting on long spurs from the main plateau. An explanation of this anomaly is still wanting, but the theory advanced by Mr. Middlemiss that local extrusion with fissure eruptions may sometimes explain the extraordinary positions of the trap to the Vindhyans seems to be supported by what has been written above regarding the detached blocks of Kaimur sandstone on the Suket shales near the trap margin. We might understand it on the assumption that large sections of the Vindhyan country subsided *en masse*, with a corresponding welling up of the molten trap to some level of equilibrium. The margins in such a case would be liable to much disturbance, slipping and disintegration. In this connection it may be noted that the only place where the Delhi series near Partabgarh show steep dips is just at their junction with the trap south-west of Malhargarh, where they suddenly curve over to a vertical position.

Central Provinces.

Mr. P. N. Datta.

93. The work in the Central Provinces was directed as before with a view to filling in the gaps in the general geological map. Mr. P. N. Datta spent the whole season mapping previously unsurveyed ground in the Chanda district. A small portion of this district in the neighbourhood of Brahmapuri (20° 35′; 79° 55′) had been examined towards the close of the previous season (1906-07), and survey work was, therefore, extended from this point eastwards, south-eastwards and southwards.

The larger portion of the area examined was found to be occupied by Archæan crystalline rocks; but Mr. Datta also mapped exposures of sandstones referred with hesitation to the Vindhyan system in some cases, and with doubt to the Gondwanas in others, as well as quartzites of probably Vindhyan age. Among the schists there are exposures of rocks resembling the typical Dharwars. A band of these, traced during the previous season as far as the latitude of Munjewara (20° 30′; 80° 8′) was followed to its termination at Wyragarh (20° 26′; 80° 9′). In the northern parts of this band, which lies partly in Bhandara and partly in Chanda, the rock varies from micaceous schist to argillite which shows little signs of alteration. Near Wyragarh these rocks strike roughly north-west to south-east and stand at a high angle. The general mass of crystalline rocks include ordinary gneiss, hornblende schist and mica-schist with occasional quartzitic rocks. These rocks occupy the lower levels, and are consequently covered by a mantle of cultivated soil, which effectually hides large areas. The eastern half of the area surveyed is occupied by rocks of a distinctly granitic character, the granites sometimes being porphyritic. Outcrops of quartz rock form prominent hills, the general geological character being not unlike that of the typical Bundelkhand areas.

Iron Ores.

Mr. Datta has drawn attention to the iron-ore deposits near Lohara (20° 24′; 79° 46′) in the Chanda district which were described by the late T. W. H. Hughes in 1873,[1] and to some other smaller occurrences of hematites. These are rich in iron, but were considered by Messrs. Tata Sons and Company to be insufficient in quantity to support any large industry conducted on a modern scale. The only other materials recorded as of possible economic value are the building stones of various kinds obtainable from the sandstones, crystalline rocks and laterite.

Kashmir.

Mr. C. S. Middlemiss.

94. The remarkably interesting discoveries in Kashmir bearing on the age of the Lower Gondwanas have been described in previous Reports.[2] During the past year Mr. C. S. Middlemiss added very

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1 *Rec., Geol. Surv. Ind.*, Vol. VI, 77.

2 General Reports for 1902-03, 1903-04 and 1906. See also H. H. Hayden, *Rec., Geol. Surv. Ind.*, Vol. XXXVI, pp. 23—39, 1907.

materially to the value of these discoveries by his unexpected find of a more complete and richly fossiliferous section in the Golabgarh pass, on his march from Jammu across the Pir Panjal range into Kashmir.

In this section Mr. Middlemiss found clearly displayed in a closely-folded syncline resting on the Panjal volcanic series :—

(*i*) Limestones, without recognisable fossils, corresponding in character and position to the Triassic limestones of other sections;
(*h*) Black shales with *Spirifer Rajah*, 10 to 20 feet thick;
(*g*) Earthy, micaceous sandstones with *Marginifera*, 300 feet thick;
(*f*) Black shales, thin bed;
(*e*) Protoretepora limestones, 200 feet thick with abundant fossils;
(*d*) Earthy and (above) calcareous sandstones;
(*c*) Sandstones and carbonaceous shales, with Lower Gondwana plants, 100 feet thick;
(*b*) Siliceous and carbonaceous shales, 180 feet thick;
(*a*) Basal conglomerate, 6 feet thick.

These beds form an apparently conformable series, from the basal conglomerate resting on the Panjal volcanics up to the limestone of probably Triassic age. The chief interests are centred in the beds (c), as in these beds Mr. Middlemiss found, in addition to *Gangamopteris* previously recognised in the Kashmir valley sections, two or three species of *Glossopteris*, with the supposed rhizome *Vertebraria indica*, and groups of leaves resembling those of *Psygmophyllum.* The *Glossopteris* remains were found in the higher beds of the series, and the order is that of the lowermost Gondwanas of the Peninsula—the Talchirs and the lowermost of the coal-bearing series, distinguished as the Karharbari beds.

Mr. Middlemiss re-examined several previously described sections of the Zewan beds and associated strata in the Kashmir valley and demonstrated beyond doubt that the Lower Trias, formerly thought not to exist in Kashmir, is present and is richly fossiliferous in places. The results of these observations are described with characteristic clearness and charm in a special paper.[1]

[1] C. S. Middlemiss, *Rec., Geol. Surv. Ind.*, Vol. XXXVII, Part 4.

THE MINERAL PRODUCTION OF INDIA DURING 1908. BY SIR T. H. HOLLAND, K.C.I.E., D.SC., F.R.S., *Director, Geological Survey of India.*

I.—INTRODUCTION.

AS this brief summary of the mineral production for 1908, will be superseded by the quinquennial Review now in course of preparation, it is purposely made short, and is confined to the minerals about which the most trustworthy regular returns are available. There are still some corrections due from the Native States, but these will probably not affect the totals seriously, and the statement is accordingly issued now for the use of those who want early information about progress.

Total Value.

The total* value of minerals raised during 1908 was returned as £7,823,745, against £7,079,708 for the same minerals in 1907, an increase of 10·5 per cent. The heavy output of coal contributed the principal share, just three-quarters of a million, to the increase, but there was also an increase in gold, petroleum, salt, saltpetre, jadestone, graphite and magnesite. On the other hand, there was a reduced output of manganese-ore, mica, ruby, tin, iron-ore, chromite and diamonds. It is likely that the fall in the price of coal and the general depression in trade which followed the extraordinary activity of 1906, 1907 and early part of 1908, will result in an interruption of the gradually ascending curve of production that has characterised the returns for the past ten years. The sharp changes in the value of chromite produced from £7,188 in 1906 to £24,404 in 1907 and back to £6,338 in 1908, show how a mineral raised on a comparatively small scale and at great distances from the coast responds readily to changes in the European market. This condition of unstable equilibrium must characterise the mining of metalliferous ores which are raised for consumption out of the country.* The fall in the value

returned for ruby, sapphire and spinel is partly due to failure to repeat in 1908 the finds of valuable sapphires which rewarded the enterprising Kashmir Mineral Syndicate in 1907, but the main part of the fall for these gem stones is due to artificial restriction of sales from the Ruby Mines district in consequence of the disturbed state of the gem market in Europe and America.

TABLE 1.—*Total Value of Minerals for which Returns of Production are available for the years 1907 and 1908.*

MINERAL.	1907.	1908.
	£	£
Coal (*a*)	2,609,726	3,356,209
Gold	2,126,756	2,177,847
Petroleum	610,015	702,009
Salt (*a*)	434,076	522,794
Manganese-ore (*b*)	589,830	465,593
Saltpetre (*b*)	274,679	292,758
Mica (*b*)	226,382	139,513
Jadestone (*b*)	49,643	73,400
Ruby, Sapphire and Spinel	98,258	47,954
Graphite	7,411	14,365
Tin-ore (*a*)	11,882	11,015
Iron-ore (*a*)	13,427	10,637
Chromite (*a*)	24,404	6,338
Magnesite (*a*)	50	2,009
Diamonds	2,784	940
Amber	385	364
TOTAL	7,079,708	7,823,745

(*a*) Spot prices. (*b*) Export values.

II.—PRODUCTION OF INDIVIDUAL MINERALS.

Chromite.

As shewn in table 2 there was a considerable decrease in the production of chromite during 1908, as compared with 1907. This was chiefly due to Mysore, where the large total of 11,197 tons was won in 1907—the first year of production—and only 856 tons sold, leaving large stocks to be carried over to 1908.

TABLE 2.—*Production of Chromite in India in 1907 and 1908.*

PROVINCE.	1907.		1908.	
	Quantity.	Value.	Quantity.	Value.
	Statute Tons.	£	Statute Tons.	£
Baluchistan	7,274	*9,699*	4,135	*5,513*
Mysore	11,029	*14,705**	610	*825* *
TOTAL .	18,303	*24,404*	4,745	*6,338*

* Estimated.

Coal.

The output of coal in 1908 amounted to 12,769,635 tons, against 11,147,339 tons in 1907, or 14·5 per cent. The average pit-mouth value was Rs. 3 as. 15 (5*s.* 3*d.*) per ton, an increase of 7 annas (7*d.*) on the average prices for 1907. The increase in production was mainly due to the Bengal coalfields, which increased their output by over 1½ million tons. The contribution by the Bengal and other Gondwana fields amounted to 12,373,018 tons, or nearly 97 per cent. of the total, only 396,617 tons being obtained from Tertiary formations during 1908. The production of each field is shown in tables 3 and 4.

TABLE 3.—*Output of Gondwana Coalfields for 1907 and 1908.*

COALFIELDS.	1907. Statute Tons	1907. Per cent. of Indian Total.	1908. Statute Tons.	1908. Per cent. of Indian Total.
Bengal—				
Daltonganj	**81,873**	0·73	**96,391**	0·76
Giridih	**750,374**	6·73	**782,763**	6·13
Jherria	**5,179,185**	46·47	**6,458,643**	50·58
Rajmahal	**257**	..	**333**	..
Raniganj	**3,981,659**	35·72	**4,221,781**	33·06
Central India—				
Umaria	**178,588**	1·60	**155,107**	1·22
Central Provinces—				
Bellarpur	**18,103**	0·16	**45,299**	0·35
Pench Valley	**74,663**	0·67	**120,249**	0·94
Mohpani	**41,322**	0·37	**48,241**	0·38
Hyderabad—				
Singareni	**414,221**	3·72	**444,211**	3·48
TOTAL, Gondwana fields	**10,720,245**	96·17	**12,373,018**	96·90

TABLE 4.—*Output of Tertiary Coalfields for 1907 and 1908.*

COALFIELDS.	1907. Statute Tons.	1907. Per cent. of Indian Total.	1908. Statute Tons.	1908. Per cent. of Indian Total.
Baluchistan—				
Khost	**29,378**	0·26	**31,547**	0·25
Sor, Mach, etc.	**13,110**	0·12	**13,665**	0·10
Eastern Bengal and Assam—				
Makum	**295,695**	2·65	**275,224**	2·15
Smaller fields	**100**	〃	..	
North-West Frontier—				
Hazara	..	..	**90**	0·43
Punjab—				
Salt Range	**47,298**	0·55	**41,407**	〃
Shahpur	**12,686**	〃	**12,685**	〃
Mianwali	**765**	〃	**702**	〃
Rajputana—				
Bikaner	**28,062**	0·25	**21,297**	0·17
TOTAL, Tertiary fields	**427,094**	3·83	**396,617**	3·10

Exports.

There was a slight rise in the quantity of coal exported in 1908, the total being 657,476 tons, with 2,120 tons of coke, against 652,971 tons of coal and 5,174 tons of coke in 1907. Ceylon as before was the principal customer, taking 424,060 tons in 1908.

Imports.

Imports at the same time increased on account of a large influx from Natal and Australia to meet the heavy demand during first half of 1908. The total quantity of coal, coke and patent fuel imported in 1908 was 385,323 tons, against 301,588 tons in 1907.

Labour.

The average daily attendance at Indian coal-mines in 1908 was 129,173, against 112,502 in 1907 and the output per person employed in 1908 was about the same, namely, 98·8 tons of coal. The output per person employed below ground in 1908 was 153·5 tons.

The death-rate from accidents at coal-mines in 1908 was noticeably higher, due largely to three serious accidents, one at Khost in Baluchistan and two on the Jherria field. The rate was 1·37 per thousand employed in 1908 against 0·89 in 1907.

Diamonds.

There was a considerable fall in the value of diamonds obtained in the Central Indian States, the returns amounting to £940 only against £2,784 in 1907.

Gold.

The rise in the value of gold produced was mainly due to increases in the Nizam's Dominions, Dharwar and on the Irrawaddy river. The provincial returns for 1907 and 1908 are compared in table 5:

TABLE 5.—*Quantity and Value of Gold produce in India during 1907 and 1908.*

PROVINCE.	1907.		1908.	
	Quantity.	Value.	Quantity.	Value.
	Ounces.	£	Ounces.	£
Bombay— Dharwar	4,916	*18,641*	7,242	*27,158*
Burma— Myitkyina	3,837	*14,919*	7,950	*30,600*
Other districts	150	*600*	150	*600*
Central Provinces	150	*600*	150	*600*
Hyderabad	13,383	*50,216*	16,437	*62,550*
Mysore	535,085	*2,041,130*	535,653	*2,055,567*
Punjab	163	*639*	195	*759*
United Provinces	2	*11*	3	*13*
TOTAL	**557,686**	*2,126,756*	**567,780**	*2,177,847*

Graphite.

There was a marked rise in the value returned for the graphite raised in the Travancore State, although the quantity produced was only slightly higher. In 1907 the total quantity reported was 2,433 tons valued at £7,411, while in 1908 the quantity was 2,873 tons valued at £14,365.

Iron-ore.

The quantity of iron-ore raised in 1908 was as follows:—

Bengal	54,466 tons.
Other Provinces and States	4,758 „
Total	59,224 „

In 1907 the total reported was 67,839 tons.

Jadeite.

There was a considerable increase in the export of jadestone through Rangoon, from 2,636 cwts. valued at £49,643 in 1907, to 3,211 cwts., valued at £73,400 in 1908.

Magnesite.

Arrangements having been made now for the calcination of magnesite on the "Chalk Hills" near Salem, systematic production has been started, the output in 1908 being 7,534 tons against a nominal production of 186 tons raised in 1907 for experimental purposes.

Manganese-ore.

Owing to the great fall in the price of manganese-ore during 1908, the production during that year was over 200,000 tons less than during 1907, but was nevertheless considerably greater than that of 1906 (571,495 tons), when the recent spell of high prices first set in. 1908 was a year of over-production, and the stocks on the mines at the end of the year were probably about 300,000 tons. The best index of the state of the industry is provided by the export returns shown in table 8. The provincial production of manganese-ore for 1907 and 1908 is shown in table 6, every province showing a decrease except Bengal and Bombay. The increase in the case of Bengal is notable and is due to the opening up of a large deposit in Gangpur State. The average number of persons employed daily at manganese mines under the control of the Indian Mines Act was 16,416 in 1908 as against 18,715 in 1907.

TABLE 6.—*Production of Manganese-ore for 1907 and 1908.*

PROVINCE.	1907.	1908.
	Statute Tons.	Statute Tons.
Bengal	2,933	20,000
Bombay	22,821	23,232
Central India	35,743	13,315
Central Provir	565,017	431,055
Madras	159,219	118,089
Mysore	113,307	68,624
TOTAL	**899,055**(*a*)	**674,315**(*a*)

(*a*) Including 15 tons extracted in Las Bela, Baluchistan, under a prospecting license.

TABLE 7.—*Production of Manganese-ore in the Central Provinces during 1907 and 1908.*

DISTRICT.	1907.	1908.
	Statute Tons.	Statute Tons.
Balaghat	163,634	135,487
Bhandara	164,203	110,673
Chhindwara	30,728	49,008
Jubbulpore	7,100	48
Nagpur	199,352	135,839
TOTAL	565,017	431,055

TABLE 8.—*Exports of Manganese-ore for the years ending 31st March 1908, and 31st March 1909.*

PORT.	1907-08.	1908-09.
	Statute Tons.	Statute Tons.
Bombay	384,115	336,896
Calcutta	42,570	24,967
Mormugao	99,962	69,820
Vizagapatam	121,735	76,150
TOTAL	648,382	507,833

Mica.

The exports of mica during 1908 fell to 27,572 cwts., valued at £139,513, from 39,055 cwts. valued at £226,382 in 1907.

Petroleum.

Increased activity in the Twingon Reserves of the Yenangyaung Oil-field, where rich oil-sands were struck at greater depths, resulted

in a marked rise in the production of petroleum during 1908, the total being 176,646,320 gallons, against 152,045,677 gallons in 1907. To the total for 1908 the Yenangyaung fields alone contributed 123,789,630 gallons. There was an increase in the export of both kerosene and paraffin wax. Of the former 5,729,114 gallons were sent out, against 1,764,075 gallons in 1907, while of paraffin wax the export amounted to 83,572 cwts. in 1908 against 76,075 cwts. in 1907.

Ruby, Sapphire and Spinel.

The despatch of rubies from Burma was artificially checked in consequence of the disturbance of the general gem market, while only sapphires of poor quality were obtained from the Zanskar workings. The value reported for these gem-stones in 1908 was only £47,954 against £98,258 in 1907.

Salt.

The salt produced in 1908 amounted to 1,279,937 tons against 1,102,783 tons in 1907. This is exclusive of the amount of sea-salt manufactured at Aden, which amounted to 88,324 tons. The rock-salt raised in the Punjab and North-West Frontier Province amounted to 113,777 tons, or 8·9 per cent. of the total production.

The foreign salt imported in 1908 amounted to 523,559 tons, against 547,169 tons in 1907.

Saltpetre.

The saltpetre exported in 1908 amounted to 386,199 cwts., valued at £292,758, against 357,589 cwts., valued at £274,679 in 1907.

Tin.

The tin raised in South Burma in 1908 amounted to 1,887 cwts., valued at £11,015, which is above the average for the past five years, but is not indicative of any real development of the industry.

III.—MINERAL CONCESSIONS GRANTED.

TABLE 9.—*Statement of Mineral Concessions Granted during 1908.*

BALUCHISTAN.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Quetta-Pishin.	(1) Babu Karam Singh for Mr. C. R. Lindsey.	Chromite . .	M. L.	80	1st July 1908	30 years.
Do. .	(2) Messrs. Essajee & Sons.	Coal . . .	M. L.	80	1st January 1908.	Do.
Do. .	(3) Do. do. .	Do. . . .	M. L.			
Do. .	(4) Mr. Deomal Khemchand.	Do. . .	P. L. .	160	15th June 1908.	1 year.
Do. .	(5) Messrs. Sorabjee & Co.	Do. . .	M. L. .	80	1st July 1908	30 years.
Do. .	(6) Khan Bahadur B. D. Patel, C.I.E.	Chromite . .	M. L. .	180	Do. .	Do.
Do. .	(7) Mr. Deomal Khemchand.	Coal . . .	M. L. .	169·76	Do. .	Do.
Do. .	(8) Messrs. Hassan Ali & Co.	Do. . .	M. L. .	12·19	Do. .	Do.
Do. .	(9) Messrs. Heera Mall S. V. & Co.	Do. . .	M. L. .	80	1st January 1909.	Do.
Do. .	(10) Mr. S. Pheroze Shaw	Do. . .	M. L. .	42	1st July 1908	Do.
Do. .	(11) Messrs. Narain Singh & Sons.	Do. . .	M. L. .	80	1st January 1909.	Do.
Sibi . .	(12) Rai Sahib Rocha Ram & Sons.	Do. . .	P. L. .	910	21st December 1908.	1 year.
Zhob . .	(13) Babu Karam Singh for Mr. C. R. Lindsey.	Chromite . .	M. L. .	160	1st July 1908	30 years.
Do. .	(14) Do. do. .	Do. . .	M. L. .	420	Do. .	Do.
Do. .	(15) The Baluchistan Mining Syndicate, Quetta.	Do. . .	M. L. .	400	Do. .	Do.
Do. .	(16) Do. do. .	Do. . .	M. L. .	450·826	Do. .	Do.
Do. .	(17) Babu Karam Singh for Mr. C. R. Lindsey.	Do. . .	M. L. .	160	Do. .	Do.
Do. .	(18) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. .	(19) Do. do. .	Do. . .	M. L. .	200	Do. .	Do.
Do. .	(20) Do. do. .	Do. . .	M. L. .	160	Do. .	Do.
Do. .	(21) The Baluchistan Mining Syndicate, Quetta.	Do. . .	M. L. .	320	Do. .	Do.
Do. .	(22) Do. do. .	Do. . .	M. L. .	100	Do. .	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease

BENGAL.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Darjeeling .	(23) P. N. Bose, Esq. .	Coal, copper, iron and other ores.	P. L. .	97	20th October 1908.	1 year
Gaya .	(24) Jhaman Singh *alias* Jung Bahadur Singh.	Mica . . .	M. L. .	148	23rd March 1908.	10 years.
Do. .	(25) Do. do. .	Do. . . .	M. L. .	25	24th June 1908.	Do.
Do. .	(26) Do. do. .	Do. . . .	M. L. .	296	Do. .	9 years and 9 months.
Hazaribagh.	(27) Mr. E. Lane .	Do. . . .	P. L. .	80	25th January 1908.	1 year.
Do. .	(28) Babu Murari Lal Singha.	Do. . . .	P. L. .	280	2nd March 1908.	Do.
Do. .	(29) Mr. S. O. Fillion .	Do. . . .	P. L. .	360	3rd March 1908.	Do.
Do. .	(30) The East Indian Mica Mining Co., Ltd.	Do. . . .	P. L. .	800	18th March 1908.	Do.
Do.	(31) J. Borer, Esq. .	Do. . . .	P. L. .	120	Do. .	Do.
Do. .	(32) E. Lane, Esq. .	Do. . . .	P. L. .	40	13th June 1908.	Do.
Do. .	(33) Do. . .	Do. . . .	P. L. .	40	Do. .	Do.
Do. .	(34) The East Indian Mica Mining Co., Ltd., through Mr. C. Murray.	Do. . . .	P. L. .	80	26th September 1908.	Do.
Do. .	(35) F. G. Talbot, Esq..	Do. . . .	P. L. .	40	15th October 1908.	Do.
Do. .	(36) Do. . .	Do. . . .	P. L. .	10	Do. .	Do.
Do. .	(37) The East Indian Mica Mining Co., Ltd.	Do. . . .	P. L. .	40	19th October 1908.	Do.
Do. .	(38) Mr. J. Borer . .	Do. . . .	P. L. .	120	21st October 1908.	Do.
Do. .	(39) Babu Murari Lal Singha.	Do. . . .	P. L. .	200	12th December 1908.	Do.
Do. .	(40) The East Indian Mica Mining Co., Ltd.	Do. . . .	P. L. .	80	18th December 1908.	Do.
Singbhum .	(41) Babu Mahdulal Doogar of Calcutta.	Manganese . .	P. L. .	128	27th January 1908.	Do.
Do. .	(42) Do. do. .	Do. . .	P. L. .	428	Do. .	Do.
Do. .	(43) Mr. Adolphe Grossmann of Calcutta.	Do. . .	P. L. .	768	Do. .	Do.
Do. .	(44) Babu Madhulal Doogar of Calcutta.	Do. . .	P. L. .	3,264	3rd February 1908.	Do.
Do. .	(45) Messrs. Martin & Co. of Calcutta.	Chromite . .	P. L. .	1,920	8th September 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BOMBAY.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Belgaum .	(46) Mr. Ramrao Bellary of Dharwar.	Manganese . .	E. L. .	1,350	Not stated .	1 year.
Do. .	(47) Mr. L. W. Grum for Mr. R. T. Coggan of Bangalore.	Do. . .	P. L. .	410	23rd March 1908.	Do.
Do. .	(48) Mr. C. P. Boyce of Belgaum.	Do. . .	E. L. .	9,060	28th May 1908.	Do.
Do. .	(49) Messrs. Glade & Co. of Bombay.	Mica . . .	E. L. .	4,374	23rd May 1908.	Do.
Do. .	(50) Messrs. Boyce & Co. of Belgaum.	Manganese . .	E. L. .	10,002	30th November 1908.	Do.
Do. .	(51) Mr. Sambshiv Iyar of Bangalore.	Do. . .	E. L. .	6,359	29th October 1908.	Do
Do. .	(52) Mr. N. F. Boyce of Gadag.	Do. . .	E. L. .	8,566	30th November 1908.	Do.
Do. .	(53) Messrs. Boyce & Co. of Belgaum.	Do. . .	E. L. .	459	Do. .	Do.
Bijápur .	(54) Mr. S. E. Chenai	Gold . . .	P. L. .	1,992	4th January 1908.	Do.
Do. .	(55) Mr. E. N. Leslie .	Manganese . .	E. L. .	5,715	16th March 1908.	Do.
Do. .	(56) Do. do. .	Do. . .	E. L. .	140	5th June 1908	Do.
Do. .	(57) B. Nagappa, Esq., Bar-at-Law, Bangalore.	Do. . .	P. L. .	313	20th August 1908.	Do.
Do. .	(58) C. P. Boyce, Esq., Belgaum.	Asbestos . .	E. L. .	821	9th July 1908	Do.
Do. .	(59) Mr. E. N. Leslie .	Manganese . .	P. L. .	1,007	3rd August 1908.	Do.
Do. .	(60) Lt.-Col. Reporter, I.M.S. (retired).	Coal . . .	P. L. .	608	2nd September 1908.	Do.
Do. .	(61) Mr. E. N. Leslie .	Manganese . .	P. L. .	291	Do. .	Do.
Do. .	(62) Do. do. .	Do. . .	P. L. .	630	Do. .	Do.
Do. .	(63) C. P. Boyce, Esq., of Belgaum.	Asbestos . .	P. L. .	1,436	4th November 1908.	Do.
Dhárwár .	(64) Mr. Ibrahimkhan Pathan.	Copper and lead .	P. L. .	85	1st February 1908.	Do.
Do. .	(65) Do. do .	Manganese . .	P. L. .	1,229	Do. .	Do.
Do. .	(66) Mr. Lallubhái Karsandás, on behalf of Messrs. Jesingbhai Maganlal & Co.	Gold, silver and other metals.	P. L. .	1,347	18th June 1908.	Do.
Do. .	(67) Mr. R. N. Bellary .	Manganese . .	E. L. .	13,354	6th April 1908	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BOMBAY—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Dhárwár .	(68) Mr. C. B. Oakley .	Gold . . .	P. L. .	3,797	8th August 1908.	1 year.
Do. .	(69) Mr. J. J. Gazdar .	Copper and lead .	P. L. .	203	27th July 1908	Do.
Do. .	(70) Do. do. .	Manganese . .	P. L. .	418	Do. .	Do.
Do. .	(71) Do. do. .	Gold . . .	P. L. .	324	Do. .	Do.
Do. .	(72) Mr. Essak Ismail .	Lead . . .	P. L. .	808	21st July 1908	Do.
Do. .	(73) Mr. B. Nagappa .	Gold . . .	P. L. .	1,157	21st September 1908.	Do.
Do. .	(74) Mr. A. S. Ismail .	Gold and copper .	P. L. .	378	20th July 1908	Do.
Do. .	(75) Mr. B. Nagappa .	Gold . .	P. L. .	476	21st September 1908.	Do.
Kánara .	(76) Messrs. Boyce & Co.	Manganese . .	P. L. .	763	31st March 1908.	Do.
Do. .	(77) Mr. D. R. Balsárwalla.	Do. . .	P. L. .	2,357	9th January 1908.	Do.
Do. .	(78) Mr. C. P. Boyce .	Do. . .	P. L. .	3,056	31st March 1908.	Do.
Do. .	(79) Mr. B. M. Doogar .	Do. . .	P. L. .	5,524	20th March 1908.	Do.
Do. .	(80) Messrs. N. Futehally & Co.	Do. . .	P. L. .	6,798	16th September 1907.	Do.
Do. .	(81) Messrs. Futehally, Manaklal & Co.	Do. . .	P. L. .	6,745	31st March 1908.	Do.
Do. .	(82) Mr. T. B. Kantharia	Do. . .	P. L. .	957	Do. .	Do.
Do. .	(83) Mr. A. Pathan .	Do. . .	P. L. .	575	Do. .	Do.
Do. .	(84) Mr. M. G. Hegde .	Do. . .	P. L. .	3,776	Do. .	Do.
Do. .	(85) Messrs. Futehally, Manaklal & Co.	Copper . .	P. L. .	2,481	Do. .	Do.
Do. .	(86) Mr. R. T. Coggan .	Manganese . .	P. L. .	1,074	Do. .	Do.
Do. .	(87) Messrs. Killick, Nixon & Co.	Do. . .	P. L. .	320	20th March 1908.	Do.
Do. .	(88) Mr. B. Nagappa .	Do. . .	P. L. .	3,515	10th May 1908	Do.
Do. .	(89) Mr. Hirachand Nemchand.	Manganese and mica.	P. L. .	2,037	30th June 1908.	Do.
Do. .	(90) Mr. P. J. Hegde .	Manganese . .	P. L. .	3,179	15th May 1908	Do.
Do. .	(91) Mr. R. N. Bellary .	Do. . .	P. L. .	1,093	15th August 1908.	Do.
Do. .	(92) Mr. M. G. Hegde .	Do. . .	P. L. .	320	5th September 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BOMBAY—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kánara .	(93) Messrs. Mahomad Husham & Co., Bombay.	Manganese . .	P. L. .	1,670	4th November 1908.	1 year.
Pánch Maháls	(94) Mr. W. C. Symes .	Do. . .	P. L. .	Whole of the Tanda estate.	31st March 1908.	Do.
Do. .	(95) Mr. Ratanlal Ranchodlal.	Do. . .	E. L. .	Not stated .	29th February 1908.	Do.
Do. .	(96) Messrs. Kahn, Kahn & Co.	Do. . .	E. L. .	2,560	31st March 1908.	Do.
Do. .	(97) Messrs. Adarji Mancherji Dalal.	Do. . .	E. L. .	2,560	28th February 1908.	Do.
Do. .	(98) Do. do. .	Do. . .	P. L. .	470	30th March 1908.	Do.
Do. .	(99) Mr. Ratanlal Ranchodlal.	Do. . .	E. L. .	1,280	29th February 1908.	Do.
Do. .	(100) Messrs. Kahn, Kahn & Co.	Do. . .	P. L. .	411	30th March 1908.	Do.
Do. .	(101) Mr. Ismailji Abdul Hussein.	Do. . .	E. L. .	Not stated .	Do. .	Do.
Do. .	(102) Mr. Karimbhoy Samsuddin.	Do. . .	P. L. .	Do. .	Do. .	Do.
Do. .	(103) Mr. Ismailji Abdul Hussein.	Do. . .	E. L. .	640	Do. .	Do.
Do. .	(104) Do. do. .	Do. . .	E. L. .	2,560	11th February 1908.	Do.
Do. .	(105) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(106) Messrs. Schroder, Smidt & Co.	Do. . .	E. L. .	5,760	16th January 1908.	Do.
Do. .	(107) Do. do. .	Do. . .	E. L. .	Not stated .	30th March 1908.	Do.
Do. .	(108) Do. do. .	Do. . .	E. L. .	Do. .	Do. .	Do.
Do. .	(109) Do. do. .	Do. . .	E. L. .	1,920	16th January 1908.	Do.
Do. .	(110) Do. do. .	Do. . .	E. L. .	5,120	Do. .	Do.
Do. .	(111) Do. do. .	Do. . .	E. L. .	2,560	10th January 1908.	Do.
Do. .	(112) Do. do. .	Do. . .	E. L. .	2,560	25th March 1908.	Do.
Do. .	(113) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(114) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(115) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BOMBAY—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Pánch Maháls	(116) Messrs. Schroder, Smidt & Co.	Manganese . .	E. L. .	2,560	25th March 1908.	1 year.
Do. .	(117) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(118) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(119) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(120) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(121) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(122) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(123) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(124) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(125) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(126) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(127) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(128) Do. do. .	Do. . .	E. L. .	2,560	Do. .	Do.
Do. .	(129) Do. do. .	Do. . .	E. L. .	2,560	31st March 1908.	Do.
Do. .	(130) Mr. F. A. H. East, Managing Agent to the Shivarajpur Syndicate of Messrs. Cory Brothers & Co., Bombay.	Do. . .	P. L. .	978	2nd May 1908	Do.
Do. .	(131) Mr. Gopáldás Vihárídás.	Do. . .	P. L. .	4	30th June 1908.	Do.
Do. .	(132) Messrs. Schroder, Smidt & Co.	Do. . .	E. L. .	640	Do. .	Do.
Do. .	(133) Messrs. Kahn, Kahn & Co.	Do. . .	E. L. .	Not stated .	30th September 1908.	Do.
Do. .	(134) Mr. Lalubhai H. Vakil.	Do. . .	P. L. .	1,600	Do. .	Do.
Do. .	(135) Mr. M. Sevadjiwan	Do. . .	P. L. .	370	14th December 1908.	Do.
Do. .	(136) Do. do. .	Do. . .	P. L. .	170	Do. .	Do.
Ratnagiri .	(137) Messrs. Nansec, Khairaz & Co., Bombay.	Graphite . .	P. L. .	10	27th April 1908.	Do.

BURMA.

Akyab .	(138) Messrs. Ezekiel & Co.	Coal . . .	E. L. .	1,167	18th September 1908.	1 year.
Amherst .	(139) Messrs. Foucar & Co.	Do. . .	E. L. .	5,816·42	1st June 1908	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Amherst .	(140) Messrs. Foucar & Co.	Antimony . .	P. L. . (renewal)	309·14	27th June 1908.	1 year.
Bhamo .	(141) Mr. A. C. Macmillan.	Gold, silver, lead and tin.	P. L. .	3,200	28th April 1908.	Do.
Henzada .	(142) The Bombay Burma Coal Syndicate.	Coal . . .	P. L. . (renewal)	2,560	19th April 1908.	Do.
Do. .	(143) Mr. G. Mills .	Do. . . .	P. L. .	3,200	30th November 1908.	Do.
Kyauksè .	(144) Mr. C. D. Clark, on behalf of Messrs. Bewick, Moreing & Co.	All minerals .	P. L. .	1,280	18th July 1908	Do.
Magwe .	(145) Mahomed Goolam Hoosein.	Petroleum . .	P. L. .	1,280	20th March 1908.	Do.
Do.	(146) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. .	P. L. .	12,800	1st May 1908	Do.
Do. .	(147) Do. do. .	Do. . .	P. L. . (renewal)	1,280	28th April 1907.	Do.
Do. .	(148) Messrs. A. S. Jamal Brothers & Co.	Do. . .	P. L. . (renewal)	640	28th March 1907.	Do.
Do. .	(149) Mahomed Goolam Hoosein Surty.	Do. . .	P. L. .	1,280	16th June 1908.	Do.
Do. .	(150) Suleman Adamjee	Do. . .	P. L. .	1,280	4th June 1908	Do.
Do. .	(151) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do. . .	P. L. . (renewal)	1,280	28th April 1908.	Do.
Do. .	(152) Messrs. A. S. Jamal Brothers & Co.	Do. . .	P. L. . (renewal)	640	28th March 1908.	Do.
Do. .	(153) Maung Kyaw E. .	Do. . .	P. L. .	180·03	23rd October 1908.	Do.
Mandalay .	(154) Messrs. Bewick, Moreing & Co.	All minerals .	P. L. .	484·8	20th January 1908.	Do.
Do. .	(155) Mr. R. C. J. Swinhoe.	Silver, lead, zinc and copper.	P. L. .	1,280	1st July 1908	Do.
Do. .	(156) The Burma Mines Railway and Smelting Co.	Iron ore . .	P. L. . (renewal)	68·83	1st August 1908.	Do.
Do. .	(157) Moolla Dawood .	All minerals .	E. L. . (renewal)	Whole district excluding areas of reserved forests.	1st October 1908.	Do.
Mergui	(158) Mr. A. B. Snow, on behalf of Burma Development Syndicate.	Tin and wolfram .	P. L. .	960	15th September 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(159) Messrs. Summers and Okeden, on behalf of Lt.-Col. K. M. Foss.	Iron and tin .	E. L. .	960	25th September 1908.	1 year.
Minbu .	(160) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Petroleum . .	P. L. .	1,600	1st January 1908.	Do
Do. .	(161) Do. do.	Do. . .	P. L. .	28, western half of 8S and eastern halves of blocks 7, 9, 11, 13, 15 and 17S of Minbu oil-winning blocks.	1st April 1908	Do.
Do.	(162) Suleman Adamjee	Do. . .	P. L. .	Half of block adjoining north of 2N, eastern halves of 3S, 4S and 6S, western halves of 7S, 10S, 11S, 12S, 13S, 16S, 17S, 18S and one sq. mile south of 17S.	28th September 1908.	Do.
Do.	(163) Maung Sit Hmaw and Maung Wa Byaw.	Gold, silver, copper and oil.	E. L. .	Over an area bounded as follows :— North— Pakôkku District. South—Man stream. East—Irrawaddy. West—Arakan Yoma.	13th August 1908.	Do.
Möngmit State.	(164) Mr. A. E. Blackwell, on behalf of the Shweli Gold Dredging and Mining Syndicate, Ltd.	Gold . . .	E. L. . (renewal)	30 sq. miles near Myitsôn, 80 miles of the Shweli river from Myitsôn to Inywa.	31st March 1908.	Do.
Do. .	(165) Do. do. .	Do. . . .	M. L. .	9 sq. miles, near Myitsôn, to the north and south of the existing banks of the Shweli river and termed the Kaukko and Kyainglon areas respectively.	1st November 1908.	30 years.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Myingyan	(166) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Petroleum	P. L.	3,504	4th October 1907.	1 year.
Do.	(167) Do. do.	Do.	P. L.	85	19th January 1908.	Do.
Do.	(168) Messrs. Noyce and Sarkies.	Do.	P. L.	1,920	30th April 1908.	Do.
Do.	(169) Messrs. Jamal Brothers & Co.	Coal and mica	P. L.	3,200	28th April 1908.	Do.
Do.	(170) Mr. J. W. Parry	Petroleum	E. L.	1,689·60	7th May 1908	Do.
Do.	(171) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do.	P. L.	1,280	27th July 1908	Do.
Do.	(172) M. Goolam Hoosein	Do.	P. L.	640	6th July 1908	Do.
Do.	(173) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Do.	P. L. (renewal)	13,440	1st May 1908	Do.
Do.	(174) Do. do.	Do.	P. L.	2,560	26th July 1908.	Do.
Do.	(175) Ma Kyi Kyi	Mica	E. L.	Not stated	31st October 1908.	Do.
Myitkyina	(176) Maung Po Kun	All minerals	E. L.	Do.	13th November 1908.	Do.
N. Shan States.	(177) Messrs. Bewick, Moreing & Co.	Silver-lead ores and associated minerals.	P. L.	3,200	6th May 1908	Do.
Do.	(178) Messrs. Mower & Co.	Gold	P. L.	1,280	21st April 1908.	Do.
Do.	(179) Do. do.	Do.	P. L.	1,280	Do.	Do.
Do.	(180) Do. do.	Silver and lead	P. L.	1,600	Do.	Do.
Do.	(181) Mr. W. R. Hillier	Antimony, tin, silver and allied metals.	P. L.	2,880	20th June 1908.	Do.
Do.	(182) Messrs. Mower & Co.	Copper and associated minerals.	P. L.	1,920	28th September 1908.	Do.
Pakôkku	(183) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Petroleum	P. L. (renewal)	1,280	3rd January 1908.	Do.
Do.	(184) Maung Po Thaik	Do.	E. L.	North—Bahin village. South—Taung-Yo village. East—Baung-bin village. West—Natt-aik Taung-Yo village.	13th January 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Pakôkku .	(185) Mr. J. W. Parry .	Petroleum . .	E. L. .	1,280	4th February 1908.	1 year.
Do. .	(186) Maung Lim Bin, representative of Maung Shwe Goh of Shwe Ôh Brothers & Co., Rangoon.	All minerals .	E. L. .	Whole district	26th May 1908	Do.
Do. .	(187) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd.	Petroleum . .	M. L. .	640	1st May 1908	30 years.
Do. .	(188) M. Goolam Hoosein	Do. . .	E. L. . (renewal)	Whole district	6th July 1908	1 year.
Do. .	(189) Messrs. J. W. Darwood & Co.	Do. . .	P. L. .	1,505	12th December 1908.	Do.
Prome .	(190) Mr. T. F. Francis, on behalf of Messrs. John Wilson and Robert Ross Macdonald.	Gold and tin .	P. L. .	6,400	1st April 1908	Do.
S. Shan States.	(191) Messrs. Mower & Co.	Silver, lead and other associated minerals.	P. L. .	3,200	6th January 1908.	Do.
Do. .	(192) Do. do. .	Do. .	P. L. .	3,200	18th June 1908.	Do.
Do. .	(193) Mr. J. Dumoulin .	Gold and silver .	P. L. .	160	12th August 1908.	Do.
Thaton .	(194) Messrs. Mower & Co.	Silver and lead .	P. L. .	2,560	27th November 1908.	Do.
Thayetmyo.	(195) Messrs. A. S. Jamal Brothers & Co.	Petroleum . .	E. L. .	38·4	29th April 1908.	Do.
Do. .	(196) Do. do. .	Do. . .	P. L. .	5,760	16th December 1908.	Do.
Do. .	(197) Do. do. .	Do. . .	P. L. .	1,280	31st October 1908.	Do.
Do. .	(198) Do. do. .	Do. . . .	P. L. .	1,280	Do. .	Do.
Toungoo .	(199) Mr. C. E. Brown .	All metals . .	P. L. . (renewal)	3,200	30th April 1908.	Do.
Do. .	(200) Mr. N. Samwell .	Gold . . .	E. L. .	Shwegyin river and its tributaries on the east of the Sittang river.	19th December 1908.	Do.
Yamethin .	(201) Mr. A. C. Macmillan, on behalf of the Mount Pima Mining Co.	Gold, silver, lead, copper and tin.	P. L. .	4,960	10th August 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(202) Mr. D. Laxminarayan of Kamptee.	Manganese . .	P. L. .	1,967	19th February 1908.	1 year.
Do. .	(203) Messrs. Ratanchand Keshrichand Chullany & Sons, Kamptee.	Do. . .	P. L. .	1,163	3rd January 1908.	Do.
Do. .	(204) Diwan Bahadur Kasturchand Daga of Kamptee.	Do. . .	P. L. .	127	20th March 1908.	Do.
Do. .	(205) Mr. Tricumdass Cooverji Bhoja of Calcutta.	Do. . .	P. L. .	1,260	9th March 1908.	Do.
Do. .	(206) Mr. C. Velu Ayah of Balaghat.	Do. . .	P. L. .	76	29th January 1908.	Do.
Do. .	(207) Mr. D. Laxminarayan of Kamptee.	Do. . .	P. L. .	64	26th February 1908.	Do.
Do. .	(208) The Indian Manganese Co.	Do. . .	M. L. .	310	27th January 1908.	30 years.
Do. .	(209) Mr. D. Laxminarayan of Kamptee.	Do. . .	P. L. .	63	19th February 1908.	1 year
Do. .	(210) Mr. Byramji Pestonji of Raipur.	Do. .	E. L.	1,485	28th January 1908.	Do.
Do. .	(211) Mr. E. G. Beckett .	Do. . .	P. L. .	48	10th February 1908.	Do.
Do. .	(212) Mr. Byramji Pestonji.	Do. . .	P. L. .	105	6th March 1908.	Do.
Do. .	(213) Mr. M. M. Mullna .	Do. . .	E. L. .	17,193	28th January 1908.	Do.
Do. .	(214) Do. do. .	Do. . .	E. L. .	15,480	31st March 1908.	Do.
Do. .	(215) Mr. Byramji Pestonji.	Do. . .	E. L. .	3,901	28th January 1908.	Do.
Do. .	(216) Singai Parmanand Sao.	Do. . .	E. L. .	1,228	29th January 1908.	Do.
Do. .	(217) Mr. Byramji Pestonji.	Do. . .	E. L. .	5,893	3rd March 1908.	Do.
Do. .	(218) Do. do. .	Do. . .	E. L. .	2,859	28th January 1908.	Do.
Do. .	(219) Mr. M. B. Chopra .	Do. . .	E. L. .	81	26th February 1908.	Do.
Do. .	(220) Do. do. .	Do. . .	E. L. .	370	Do. .	Do.
Do. .	(221) Singai Parmanand Sarupchand.	Do. . .	E. L. .	921	29th January 1908.	Do.
Do. .	(222) Do. do. .	Do. . .	E. L. .	562	Do. .	Do.
Do. .	(223) Mr. C. Velu Ayah .	Do. . .	P. L. .	104	23rd March 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(224) Messrs. Tata Sons & Co.	Manganese . .	E. L. .	2,313	30th March 1908.	1 year.
Do. .	(225) Mr. M. B. Chopra .	Do. . .	E. L. .	548	26th February 1908.	Do.
Do. .	(226) Do. do. .	Do. . .	E. L. . .	159	Do. .	Do.
Do. .	(227) Diwan Bahadur Kasturchand Daga.	Do. . .	P. L. .	64	20th March 1908.	Do.
Do. .	(228) Mr. M. M. Mullna .	Do. . .	P. L. .	193	12th March 1908.	Do.
Do. .	(229) Messrs. Ganesh Prasad and Janki Prasad.	Do. . .	P. L. .	348	31st March 1908.	Do.
Do. .	(230) Do. do. .	Do. . .	P. L. .	23	13th March 1908.	Do.
Do. .	(231) Babu Kripa Shanker.	Do. . .	E. L. .	387	7th March 1908.	Do.
Do. .	(232) Rai Sahib Mathura Prasad and Motilal.	Do. . .	P. L. .	18	22nd June 1908.	Do.
Do .	(233) Do. do. .	Do . .	P. L. .	5	3rd June 1908	Do.
Do. .	(234) Mr. Bhudar Sao .	Do. . .	P. L. .	143	Do. .	Do.
Do. .	(235) Lala B. Sitaram .	Do. . .	E. L. .	328	30th May 1908	Do.
Do. .	(236) Mr. M. M. Mullna .	Do. . .	P. L. .	68	15th June 1908.	Do.
Do. .	(237) Diwan Bahadur Kasturchand Daga.	Do. . .	P. L. .	8	3rd June 1908	Do.
Do. .	(238) Mr. D. Laxminarayan.	Do. . .	P. L. .	73	4th April 1908	Do.
Do. .	(239) Diwan Bahadur Kasturchand Daga.	Do. . .	P. L. .	9	3rd June 1908	Do.
Do. .	(240) Mr. Byramji D. Dungaji.	Do. . .	P. L. .	6	Do. .	Do.
Do. .	(241) Messrs. Ramprasad and Laxminarayan.	Do. . .	P. L. .	15	19th May 1908	Do.
Do. .	(242) Mr. J. W. Parry .	Do. . .	E. L. .	4,289	22nd May 1908	Do.
Do. .	(243) Do. do. .	Do. . .	E. L. .	2,835	Do. .	Do.
Do. .	(244) Do. do. .	Do. . .	E. L. .	1,207	Do. .	Do.
Do. .	(245) Diwan Bahadur Kasturchand Daga.	Do. . .	P. L. .	509	11th April 1908.	Do.
Do. .	(246) Messrs. Dutt, Burn & Co.	Do. . .	M. L. .	10	23rd May 1908	30 years.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(247) Messrs. Lall Behari Naraindas and Ramcharan Shunker Lall.	Manganese . .	P. L. .	34	3rd June 1908	1 year.
Do. .	(248) Do. do. .	Mica . . .	P. L. .	69	Do. .	Do.
Do. .	(249) Mr. Bhudhar Sao .	Manganese . .	E. L. .	2,231	Do. .	Do.
Do. .	(250) Lala B. Sitaram .	Do. . .	E. L. .	742	30th May 1908	Do.
Do. .	(251) Mr. Byramji Pestonji	Do. . .	E. L. .	4,801	12th June 1908	Do.
Do. .	(252) Babu Kripa Shanker.	Do. . .	E. L. .	1,233	3rd June 1908	Do.
Do. .	(253) Do. do. .	Do. . .	E. L. .	412	Do. .	Do.
Do. .	(254) Do. do. .	Do. . .	E. L. .	523	Do. .	Do.
Do. .	(255) Mr. Byramji Pestonji	Do. . .	E. L.	7,819	12th June 1908	Do.
Do. .	(256) Mr. Hiralal Sukul .	Do. . .	P. L. .	18	21st May 1908	Do.
Do. .	(257) Mr. Byramji Pestonji	Do. . .	E. L. .	7,165	12th June 1908	Do.
Do. .	(258) Do. do. .	Do. . .	E. L. .	5,471	Do. .	Do.
Do. .	(259) Messrs. Gaur Ratansha & Co.	Do. . .	E. L. .	2,471	28th May 1908	Do.
Do. .	(260) The Nagpur Manganese Mining Syndicate.	Do. . .	E. L. .	22	6th June 1908	Do.
Do. .	(261) Diwan Bahadur Kasturchand Daga.	Do. . .	P. L. .	834	10th August 1908.	Do.
Do. .	(262) Mr. M. M. Mullna .	Do. . .	P. L. .	103	21st September 1908.	Do.
Do. .	(263) Do. do. .	Do. . .	P. L. .	204	Do. .	Do.
Do. .	(264) Rai Sahib Mathura Prasad and Motilal.	Do. . .	P. L. .	182	9th July 1908	Do.
Do. .	(265) Do. do. .	Do. . .	M. L. .	183	18th August 1908.	30 years.
Do. .	(266) The Central Provinces Prospecting Syndicate.	Do. . .	M. L. .	26	2nd June 1908	Do.
Do. .	(267) Singai Parmanand Sarupchand.	Do. . .	P. L. .	74	20th July 1908	1 year.
Do. .	(268) Messrs. B. B. B. Fouzdar & Brothers.	Do. . .	P. L. .	173	28th September 1908.	Do.
Do. .	(269) Mr. Hiralal Sukul .	Do. . .	P. L. .	763	Do. .	Do.
Do. .	(270) Diwan Bahadur Kasturchand Daga.	Do. . .	P. L. .	42	16th September 1908.	Do.
Do. .	(271) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	33	25th August 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(272) Mr. M. M. Gupta .	Manganese . .	P. L. .	272	30th August 1908.	1 year.
Do. .	(273) Mr. Byramji Pestonji.	Do. . .	P. L. .	414	29th September 1908.	Do.
Do. .	(274) Raja Gokul Dass of Jubbulpore.	Do. . .	P. L. .	68	21st September 1908.	Do.
Do. .	(275) The Jubbulpore Prospecting Syndicate.	Do. . .	P. L. .	176	Do. .	Do.
Do. .	(276) Mr. D. Laxminarayan.	Mica . . .	P. L. .	285	24th September 1908.	Do.
Do. .	(277) Diwan Bahadur Kasturchand Daga.	Manganese . .	P. L. .	22	16th September 1908.	Do.
Do. .	(278) Do. do. .	Do. . .	P. L. .	46	9th July 1908	Do.
Do. .	(279) Do. do. .	Do. . .	P. L. .	25	5th August 1908.	Do.
Do. .	(280) Mr. C. Velu Ayah .	Do. . .	P. L. .	81	27th July 1908.	Do.
Do. .	(281) The Nagpur Manganese Mining Syndicate.	Do. . .	P. L. .	18	11th August 1908.	Do.
Do. .	(282) Thakur Paiku Singh.	Do. . .	P. L. .	18	3rd July 1908	Do.
Do. .	(283) Mr. P. N. Bose .	Do. . .	E. L. .	2,080	3rd August 1908.	Do.
Do. .	(284) Mr. Byramji Pestonji.	Do. . .	P. L. .	53	3rd September 1908.	Do.
Do. .	(285) Mr. Lalbihari Naraindas.	Do. . .	P. L. .	202	26th September 1908.	Do.
Do. .	(286) Babu Nago Bhimji	Do. . .	P. L. .	78	22nd September 1908.	Do.
Do. .	(287) Mr. A. C. Blechynden.	Do. . .	P. L. .	20	28th September 1908.	Do.
Do. .	(288) Babu Nago Bhimji	Do. . .	P. L. .	28	22nd September 1908.	Do.
Do. .	(289) Mr. Byramji D. Doongaji.	Do. . .	P. L. .	6	12th August 1908.	Do.
Do. .	(290) Messrs. Schroder, Smidt & Co., Calcutta.	Do. . .	E. L. .	1,695	14th July 1908	Do.
Do. .	(291) Mr. C. Velu Ayah .	Do. . .	M. L. .	127	17th September 1908.	30 years.
Do. .	(292) Messrs. Ramprasad and Laxminarain.	Do. . .	E. L. .	142	16th August 1908.	Do.
Do. .	(293) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	27	25th August 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(294) Messrs. Tata Sons & Co.	Bauxite . .	P. L. .	8,639	13th October 1908.	1 year.
Do.	(295) Mr. M. B. Chopra.	Manganese .	P. L. .	98	18th December 1908.	Do.
Do. .	(296) Lala B. Sitaram .	Do. . .	P. L. .	328	10th November 1908.	Do.
Do. .	(297) Do. do. .	Do. . .	P. L. .	742	Do. .	Do.
Do. .	(298) Mr. D. Laxminarain.	Do. . .	M. L. .	340	19th November 1908.	30 years.
Do. .	(299) Lala B. Sitaram .	Mica . . .	P. L. .	170	18th December 1908.	1 year.
Do. .	(300) Do. do. .	Do. . .	P. L. .	91	10th November 1908.	Do.
Do. .	(301) Mr. E. G. Beckett, Kamptee.	Manganese . .	P. L. .	85	13th October 1908.	Do.
Do. .	(302) Babu E. Naganna Naidu.	Do. . .	P. L. .	21	1st December 1908.	Do.
Do. .	(303) Mr. S. O. Holmes .	Do. . .	P. L. .	203	19th December 1908.	Do.
Do. .	(304) Mr. M. M. Mulina .	Do. . .	P. L. .	88	18th December 1908.	Do.
Do. .	(305) Mr. Bhudhar Sao .	Do. . .	P. L. .	20	21st December 1908.	Do.
Do. .	(306) The Central Provinces Prospecting Syndicate, Kamptee.	Do. . .	M. L. .	411	14th October 1908.	30 years.
Do. .	(307) Mr. A. C. Blechynden.	Do. . .	P. L. .	100	31st October 1908.	1 year.
Do. .	(308) Do. do. .	Do. . .	P. L. .	131	22nd October 1908.	Do.
Do. .	(309) Do. do. .	Do. . .	P. L. .	105	Do. .	Do.
Do. .	(310) Mr. Lalbihari Naraindas of Kamptee.	Do. . .	M. L. .	42	13th October 1908.	5 years.
Do. .	(311) Mr. A. C. Blechynden.	Do. . .	P. L. .	213	11th November 1908.	1 year.
Do. .	(312) Mr. Bhudhar Sao .	Do. . .	P. L. .	81	21st December 1908.	Do.
Do. .	(313) Babu Nago Bhimji	Do. . .	P. L. .	273	26th November 1908.	Do.
Do. .	(314) Mr. T. B. Kantharia.	Do. . .	P. L. .	95	1st December 1908.	Do
Do. .	(315) Messrs. Kassambhoy, Gopaldas and Mahadeo Seth.	Do. . .	P. L. .	5	12th November 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(316) Messrs. Ramprasad and Laxminarain.	Manganese	P. L.	140	18th November 1908.	1 year.
Do.	(317) Lala B. Sitaram	Mica	E. L.	146	10th November 1908.	Do.
Do.	(318) Messrs. Oomarali Brothers.	Manganese	E. L.	1,265	16th October 1908.	Do.
Do.	(319) Babu Kripa Shanker.	Do.	E. L.	724	11th November 1908.	Do.
Do.	(320) Do. do.	Do.	E. L.	628	Do.	Do.
Betul	(321) Mr. P. E. Cameron	Coal	P. L.	12,821	11th April 1908.	Do.
Do.	(322) Mr. P. C. Dutt	Do.	E. L.	34,239	13th June 1908.	Do.
Do.	(323) Mr. R. K. Kanga	Do.	E. L.	2,790	5th May 1908	Do.
Do.	(324) Mr. M. M. Mullna	Do.	P. L.	700	21st October 1908.	Do.
Do.	(325) Mr. R. K. Kanga	Do.	P. L.	2,790	21st December 1908.	Do.
Do.	(326) Mr. Khimji Cooverji, Bombay.	Do.	P. L.	2,055	15th November 1908.	Do.
Do.	(327) Seth Lakhmichand of Badnur.	Graphite and corundum.	P. L.	1,283	15th December 1908.	Do.
Do.	(328) Mr. Hanmantrao, Mohitey, Kamptee.	All minerals	P. L.	208	23rd December 1908.	Do.
Do.	(329) The Hon'ble Sir Vithaldas Thackersay.	Coal	P. L.	37,142	16th December 1908.	Do.
Bhandara	(330) Rai Sahib Mathura Prasad and Motilal.	Manganese	P. L.	782	10th February 1908.	Do.
Do.	(331) Diwan Bahadur Kasturchand Daga.	Do.	P. L.	185	8th January 1908.	Do.
Do.	(332) Messrs. Cursetji & Co.	Do.	P. L.	37	3rd January 1908.	Do.
Do.	(333) Mr. Rambilas Murlidhar.	Do.	P. L.	337	Do.	Do.
Do.	(334) Mr. D. Laxminarain.	Do.	M. L.	22	6th February 1908.	30 years
Do.	(335) Mr. Shamji Madhoji.	Do.	P. L.	441	25th December 1907.	1 year.
Do.	(336) Mr. Byramji Pestonji.	Do.	E. L.	200	28th January 1908.	Do.
Do.	(337) Mr. Hiralal Sukul	Do.	P. L.	500	25th January 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(338) Lala B. Sitaram .	Manganese . .	P. L. .	95	3rd March 1908.	1 year.
Do. .	(339) Rai Sahib Mathura Prasad.	Do. . .	P. L. .	4	10th February 1908.	Do.
Do. .	(340) Messrs. B. B. B. Fouzdar & Bros.	Do. . .	P. L. .	61	31st January 1908.	Do.
Do. .	(341) Rai Sahib Mathura Prasad and Motilal.	Do. . .	P. L. .	102	10th February 1908.	Do.
Do. .	(342) Messrs. B. B. B. Fouzdar & Bros.	Do. . .	P. L. .	61	31st January 1908.	Do.
Do. .	(343) Mr. S. S. Wazalwar	Do. . .	E. L. .	144	Not stated .	Do.
Do. .	(344) Do. do. .	Do. . .	E. L. .	290		Do.
Do. .	(345) Mr. Darasha Mancherji.	Do. . .	P. L. .	8	8th January 1908.	Do.
Do. .	(346) Mr. G. P. Jaideo Prasad.	Do. . .	P. L. .	127	5th March 1908.	Do.
Do. .	(347) Mr. R. B. Onkardass.	Do. . .	P. L. .	15	Do. .	Do.
Do. .	(348) Mr. Darasha Mancherji.	Do. . .	P. L. .	10	10th February 1908.	Do.
Do. .	(349) Do. do. .	Do. . .	P. L. .	2	16th February 1908.	Do.
Do. .	(350) Messrs. Kasambhoy Ramji & Co.	Do. . .	E. L. .	258	6th December 1907.	Do.
Do. .	(351) Mr. Byramji Pestonji.	Do. . .	E. L. .	968	17th January 1908.	Do.
Do. .	(352) Mr. Darashaw Mancherji Doongaji.	Do. . .	E. L. .	421	6th December 1907.	Do.
Do. .	(353) Mr. D. N. Mitra .	Do. . .	P. L. .	15	26th March 1908.	Do.
Do. .	(354) Mr. Darashaw Mancherji D. Doongaji.	Do. . .	E. L. .	10	3rd January 1908.	Do.
Do. .	(355) Mr. Kashinath Ramchandra.	Do. . .	P. L. .	27	28th February 1908.	Do.
Do. .	(356) Messrs. Cursetji & Co.	Do. . .	P. L. .	40	30th April 1908.	Do.
Do. .	(357) Mr. D. Laxminarain.	Do. . .	M. L. .	216	9th April 1908	30 years.
Do. .	(358) Rai Sahib Mathura Prasad and Motilal.	Do. . .	E. L. .	2,592	29th April 1908.	1 year.
Do. .	(359) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	89	12th May 1908	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Terms.
Bhandara .	(360) Mr. Jagannath Balaram.	Manganese . .	P. L. .	55	10th March 1908.	1 year.
Do. .	(361) Mr. G. R. Indurkar	Do. . .	P. L. .	1	30th April 1908.	Do.
Do. .	(362) Mr. Darasha Mancherji.	Do. . .	P. L. .	774	22nd March 1908.	Do.
Do. .	(363) Mr. D. N. Mitra .	Do. . .	P. L. .	108	30th April 1908.	Do.
Do. .	(364) Mr. Munnalal Tiwari	Do. . .	P. L. .	42	20th June 1908.	Do.
Do. .	(365) Mr. R. B. Onkardass.	Do. . .	E. L. .	15	17th March 1908.	Do.
Do. .	(366) Mr. T. B. Kantharia.	Do. . .	P. L. .	56	19th June 1908.	Do.
Do. .	(367) Lala Ganesh Prashad and Janki Prashad.	Do. . .	E. L. .	Not stated .	14th June 1908.	Do.
Do. .	(368) Mr. Wasudeo Trimbak Shendey.	Do. . .	E. L. .	164	18th May 1908	Do.
Do. .	(369) Mr. Lalbihari Naraindas.	Do. . .	P. L. .	95	29th April 1908.	Do.
Do. .	(370) Babu Madhulal Doogar.	Do. . .	P. L. .	63	17th July 1908	Do.
Do. .	(371) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	94	25th June 1908.	Do.
Do. .	(372) Diwan Bahadur Kasturchand Daga.	Do. . .	E. L. .	709	6th July 1908	Do
Do. .	(373) Mr. Jagannath Ballabhram.	Do. . .	P. L. .	10	21st September 1908.	Do.
Do. .	(374) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	863	24th September 1908.	Do.
Do. .	(375) Mr. S. S. Wazalwar	Do. . .	P. L. .	17	18th July 1908	Do.
Do. .	(376) Do. do. .	Do. . .	P. L. .	44	25th July 1908	Do.
Do. .	(377) Mr. Lalbihari Naraindas.	Do. . .	P. L. .	270	18th July 1908	Do.
Do. .	(378) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	52	20th July 1908	Do.
Do. .	(379) Mr. Byramji Pestonji.	Do. . .	P. L. .	8	20th August 1908.	Do.
Do. .	(380) Mr. P. Balkrishna Naidu.	Do. . .	P. L. .	15	7th July 1908	Do.
Do. .	(381) Mr. Hiralal Sukul .	Do. . .	P. L. .	217	25th August 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(382) Messrs. Kassambhoy Ramji & Co.	Manganese . .	E. L. .	315	23rd December 1907.	1 year.
Do. .	(383) Messrs. P. S. Kotwal and S. R. Naidu.	Do. . .	P. L. .	155	2nd September 1908.	Do.
Do. .	(384) Rai Sahib Mathura Prasad and Motilal.	Do. . .	E. L. .	Not stated .	5th June 1908	Do.
Do. .	(385) Mr. Wasudeo Trimbak Shendey.	Do. . .	P. L. .	253	14th July 1908	Do.
Do. .	(386) Mr. T. B. Kantharia	Do. . .	P. L. .	50	19th June 1908.	Do.
Do. .	(387) Babu E. Nagannah Naidu.	Do. . .	P. L. .	57	8th July 1908	Do.
Do. .	(388) Mr. W. T. Shendey	Do. . .	P. L. .	165	14th July 1908	Do.
Do. .	(389) Mr. Byramji Pestonji.	Do. . .	E. L. .	3,043	16th March 1908.	Do.
Do. .	(390) Mr. W. T. Shendey.	Do. . .	P. L. .	104	14th July 1908	Do.
Do. .	(391) Mr. Lalbihari Naraindas.	Do. . .	P. L. .	2	13th May 1908	Do.
Do. .	(392) The Central India Mining Co., Ltd.	Do. . .	P. L. .	19	16th June 1908.	Do.
Do. .	(393) Mr. B. K. Kanga .	Do. . .	E. L. .	1,300	1st September 1908.	Do.
Do. .	(394) Mr. W. T. Shendey	Do. . .	E. L. .	252	25th May 1908	Do.
Do. .	(395) Mr. Byramji Pestonji.	Coal . . .	E. L. .	631	30th June 1908.	Do.
Do. .	(396) Diwan Bahadur Kasturchand Daga.	Manganese . .	P. L. .	26	17th September 1908.	Do.
Do. .	(397) The Central India Mining Co., Kamptee.	Do. . .	P. L. .	674	17th October 1908.	Do.
Do. .	(398) Do. do. .	Do. . .	P. L. .	933	31st December 1908.	Do.
Do. .	(399) Mr. Byramji Pestonji of Raipur.	Do. . .	E. L. .	151	8th October 1908.	Do.
Do. .	(400) Mr. D. Laxminarain.	Do. . .	M. L. .	80	18th November 1908.	30 years.
Do. .	(401) Mr. G. M. Prichard	Do. . .	M. L. .	201	8th September 1908.	Do.
Do. .	(402) Mr. D. Gangadhar Rao.	Do. . .	P. L. .	42	28th November 1908.	1 year.
Do. .	(403) Mr. Shamji Madhoji.	Do. . .	P. L. .	294	21st October 1908.	Do.
Do. .	(404) Mr. Byramji Pestonji.	Do. . .	P. L. .	91	2nd December 1908.	Do.

E. L. denotes Exploring License, P. L. Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(405) Mr. Jagannath Ballabhram.	Manganese . .	P. L. .	136	21st December 1908.	1 year.
Do. .	(406) Mr. Shamji Madhoji.	Do. . .	P. L. .	67	21st October 1908.	Do.
Do. .	(407) Messrs. Lal Behari Narayandas and Ramcharan Shanker Lal of Kamptee.	Do. . .	P. L. .	56	5th December 1908.	Do.
Do. .	(408) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	39	5th November 1908.	Do.
Do. .	(409) Lala Ganesh Prasad and Janki Prasad.	Do. . .	P. L. .	104	19th November 1908.	Do.
Do. .	(410) Messrs. B. B. B. Fouzdar & Bros.	Do. . .	P. L. .	81	25th November 1908.	Do.
Do. .	(411) Mr. R. H. Richardson.	Do. . .	P. L. .	59	7th November 1908.	Do.
Do. .	(412) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	30	28th October 1908.	Do.
Do. .	(413) Mr. Cooverji Bhoja, Calcutta.	Do. . .	M. L. .	23	6th October 1908.	30 years
Do. .	(414) Rai Sahib Mathura Prasad and Motilal.	Do. . .	M. L. .	34	29th September 1908.	Do.
Do. .	(415) Mr. P. Balkrishna Naidu.	Do. . .	P. L. .	275	25th November 1908.	1 year.
Do. .	(416) Mr. Hiralal Sukul .	Do. . .	P. L. .	99	5th November 1908.	Do.
Do. .	(417) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth, Kamptee.	Do. . .	P. L. .	209	8th October 1908.	Do.
Do. .	(418) Do. do. .	Do. . .	P. L. .	31	Do. .	Do.
Do. .	(419) Do. do. .	Do. . .	P. L. .	8	16th October 1908.	Do.
Do. .	(420) Mr. Byramji Pestonji.	Do. . .	E. L. .	182	24th October 1908.	Do.
Do. .	(421) Messrs. Martin & Co.	All minerals .	P. L. .	2,730	25th November 1908.	Do.
Do. .	(422) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth.	Manganese . .	P. L. .	77	16th October 1908.	Do.
Do. .	(423) Do. do. .	Do. . .	P. L. .	6	8th October 1908.	Do.
Do. .	(424) Mr. P. Balkrishna Naidu.	Do. . .	P. L. .	92	4th November 1908.	Do.
Do. .	(425) Mr. Taiballi Kamruddin.	Do. . .	E. L. .	413	3rd December 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bilaspur .	(426) Mr. W. Thompson.	Coal . . .	E. L. .	Not stated .	15th February 1908.	1 y a
Do. .	(427) Mr. R. K. Kanga .	Limestone . .	E. L. .	4,659	21st September 1908.	Dc
Do. .	(428) Do. do. .	Coal . . .	E. L. .	6,337	Do. .	Dc
Chanda .	(429) Mr. G. Ramaswamy.	Copper . .	P. L. .	37	22nd September 1908.	Do
Do. .	(430) Do. do. .	Do. . .	P. L. .	215	Do. .	Do
Chhindwara.	(431) Seths Ramlal and Sukhlal.	Manganese . .	P. L. .	537	31st March 1908.	Do.
Do. .	(432) Rai Sahib Mathura Prasad and Motilal.	Do. . .	P. L. .	72	18th February 1908.	Do.
Do. .	(433) Do. do. .	Do. . .	P. L. .	63	31st March 1908.	Do.
Do. .	(434) Seths Ramlal and Sukhlal.	Do. . .	P. L. .	218	15th January 1908.	Do.
Do. .	(435) Messrs. V. D. Salpekar and Kartarbux.	Do. . .	P. L. .	276	Do. .	Do.
Do. .	(436) Mr. R. H. Richardson.	Do. . .	P. L. .	519	30th March 1908.	Do.
Do. .	(437) Rai Sahib Mathura Prasad and Motilal.	Do. . .	P. L. .	176	31st March 1908.	Do.
Do. .	(438) Messrs. Tarachand Sao and others.	Do. . .	P. L. .	365	8th January 1908.	Do.
Do. .	(439) Rai Sahib Mathura Prasad and Motilal.	Do. . .	P. L. .	96	31st March 1908.	Do.
Do. .	(440) Messrs. V. D. Salpekar and Kartarbux.	Do. . .	P. L. .	207	Do. .	Do.
Do. .	(441) Messrs. H. Verma and K. Lall.	Do. . .	P. L. .	105	Do. .	Do.
Do. .	(442) Messrs. Shaw, Wallace & Co.	Coal . . .	P. L. .	486	24th January 1908.	Do.
Do. .	(443) Messrs. H. Verma and Kanhaiyalal.	Manganese . .	P. L. .	127	21st January 1908.	Do.
Do. .	(444) Mr. Muhammad Akbar Khan and others.	Do. . .	P. L. .	175	31st March 1908.	Do.
Do. .	(445) The Hon'ble Mr. G. M. Chitnavis.	Do. . .	P. L. .	46	Do. .	Do.
Do. .	(446) Rai Sahib Mathura Prasad and Motilal.	Do. . .	P. L. .	18	30th June 1908.	Do.
Do. .	(447) Seths Ramlal and Sukhlal.	Do. . .	P. L. .	476	Do. .	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(448) Rai Sahib Mathura Prasad and Motilal.	Manganese .	M. L.	61	4th May 1908	30 years.
Do.	(449) Seths Ramlal and Sukhlal.	Do.	P. L.	91	30th June 1908.	1 year.
Do.	(450) Khan Bahadur Ali Raza Khan.	Do.	P. L.	96	1st April 1908	Do.
Do.	(451) Mr. M. B. Dadabhoy	Do.	P. L.	644	30th June 1908.	Do.
Do.	(452) The Upper Pench Coal Co., Ltd.	Coal	M. L.	2,607	1st May 1908	30 years.
Do.	(453) Messrs. V. D. Salpekar and Kartarbux.	Manganese .	P. L.	410	14th August 1908.	1 year.
Do.	(454) Messrs. Motilal, Jagannath and Lakhmichand.	Do.	P. L.	277	4th July 1908	Do.
Do.	(455) Messrs. Mohammad Akbar & Co.	Do.	P. L.	920	5th August 1908.	Do.
Do.	(456) Mr. L. Grossmann.	Coal	P. L.	7,013	15th August 1908.	Do.
Do.	(457) Rai Sahib Mathura Prasad and Motilal.	Manganese .	P. L.	23	15th July 1908	Do.
Do.	(458) Messrs. V. D. Salpekar and Kartarbux.	Mica	P. L.	168	14th August 1908.	Do
Do.	(459) Mr. W. Stalkart	Manganese .	P. L.	200	28th September 1908.	Do.
Do.	(460) Mr. D. N. Mitra	Coal	P. L.	4,256	30th September 1908.	Do.
Do.	(461) Rai Sahib Mathura Prasad and Motilal.	Do.	P. L.	433	24th September 1908.	Do.
Do.	(462) Mr. M. B. Dadabhoy.	Do.	E. L.	2,026	27th July 1908	Do.
Do.	(463) The Hon'ble Mr. G. M. Chitnavis.	Manganese .	P. L.	124	6th November 1908.	Do.
Do.	(464) Messrs. Motilal, Jagannath and Lakhmichand.	Do.	P. L.	430	9th December 1908.	Do.
Do.	(465) The Indian Manganese Mining Co.	Do.	M. L.	64	8th November 1908.	30 years.
Do.	(466) Govind Rao Baji Rao.	Do.	P. L.	20	3rd November 1908.	1 year.
Do.	(467) Mr. Cooverji Bhoja	Coal	P. L.	337	7th October 1908.	Do.
Do.	(468) Messrs. Motilal, Jagannath and Lakhmichand.	Manganese .	P. L.	65	9th December 1908.	Do.
Do.	(469) Do. do.	Mica	P. L.	81	Do.	Do

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara .	(470) Mr. M. B. Dadabhoy.	Coal . . .	P. L. .	2,026	5th December 1908.	1 year.
Damoh .	(471) R. B. Damodhar Rao.	All minerals .	E. L. .	61,760	24th February 1908.	Do.
Drug . .	(472) Dr. H. S. Gaur, Ratanshaw & Co.	Lead, zinc, aluminium, manganese and graphite.	E. L. .	1,317	22nd July 1908.	Do.
Do. .	(473) Messrs. B. B. B. Fouzdar & Bros.	Platinum, wolfram, tin, bauxite and manganese.	P. L. .	84	10th November 1908.	Do.
Hoshangabad	(474) Mr. B. L. Rai of Saugor.	All minerals .	E. L. .	150	15th February 1908.	Do.
Jubbulpore.	(475) Messrs. Olpherts & Co., Murwara.	Red iron ore and manganese.	P. L. .	69	9th March 1908.	Do.
Do. .	(476) Babu E. Nagannah Naidu.	Manganese . .	P. L. .	346	19th January 1908.	Do.
Do. .	(477) Messrs. Burn & Co. and Mr. P. C. Dutt.	Gold, silver, lead, copper, arsenic, iron, manganese, limestone, zinc, dolomite, barytes, tin and antimony.	P. L. .	2,788	16th September 1907.	6 months.
Do. .	(478) Mr. Shirish Chander Roy Chaudhry.	Manganese and iron.	E. L. .	50	28th February 1908.	1 year.
Do. .	(479) R. B. Beharilal Khazanchi, Jubbulpore.	Do. . .	E. L. .	25	31st March 1908.	Do.
Do. .	(480) The Bombay Mining and Prospecting Syndicate.	Soapstone, steatite, talc and asbestos.	E. L. .	3,451	23rd March 1908.	Do.
Do. .	(481) Do. do. .	Bauxite . .	P. L. .	1,044	1st June 1908	Do.
Do. .	(482) Messrs. Burn & Co. and Mr. P. C. Dutt.	Soapstone, steatite and talc.	M. L. .	280	9th May 1908	30 years.
Do. .	(483) Rao Bahadur Ganpat Rao Gopal Ghatate.	Manganese . .	P. L. .	124	22nd April 1908.	1 year.
Do. .	(484) Mr. M. B. Chopra .	Do. . .	P. L. .	229	1st June 1908	Do.
Do. .	(485) Mr. Shirish Chander Roy Choudhry.	Manganese and iron.	P. L. .	75	6th June 1908	Do.
Do. .	(486) Messrs. C. Macdonald & Co.	Copper, lead, silver, manganese, gold and zinc.	E. L. .	5,843	22nd April 1908.	Do.
Do. .	(487) The Bombay Prospecting and Mining Syndicate.	Bauxite, lithomarge and china clay.	E. L. .	1,710	Do. .	Do.
Do. .	(488) Mr. J. W. A. Macdonald.	Bauxite and aluminium.	E. L. .	7,180	23rd April 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore.	(489) The Bombay Prospecting and Mining Syndicate.	Steatite, talc and soapstone.	E. L.	2,872	9th May 1908	1 year.
Do.	(490) Mr. Shirish Chander Roy Chaudhury.	Gold, silver, lead and copper.	M. L.	35	14th July 1908	15 years.
Do.	(491) Lala Ganesh Prasad, Janki Prasad & Bros.	Silver, manganese, copper and iron.	P. L.	100	15th September 1908.	1 year.
Do.	(492) Messrs. H. F. Cook & Sons, Murwara.	Gold, silver, copper, lead, iron, red clay and manganese.	P. L.	72	11th August 1908.	Do.
Do.	(493) Mr. Hiralal Sukul	Manganese	P. L.	49	9th July 1908	Do.
Do.	(494) Lala Ganesh Prasad, Janki Prasad & Bros.	Do.	P. L.	48	15th September 1908.	Do.
Do.	(495) The Bombay Prospecting and Mining Syndicate.	Gold, silver, copper, lead and coal.	E. L.	1,434	14th July 1908	Do.
Do.	(496) Do. do.	Gold, silver, copper, lead and platinum.	E. L.	927	Do.	Do.
Do.	(497) Mr. P. C. Dutt, Bar-at-Law.	Gold, silver, copper and lead.	E. L.	1,587	13th July 1908	Do.
Do.	(498) Do. do.	Bauxite	P. L.	294	21st June 1908.	Do.
Do.	(499) The Bombay Prospecting and Mining Syndicate.	Do.	E. L.	423	14th July 1908	Do.
Do.	(500) The Jubbulpore Bar Mining Association.	Gold, silver, copper and lead.	E. L.	971	Do.	Do.
Do.	(501) The Bombay Prospecting and Mining Syndicate.	Steatite	E. L.	220	28th August 1908.	Do.
Do.	(502) Seth Tehmusji Cowasji, Murwara.	Coal	E. L.	1,675	9th December 1908.	Do.
Nagpur	(503) The Central Provinces Prospecting Syndicate.	Manganese	P. L.	34	27th February 1908.	Do.
Do.	(504) Mr. D. Laxminarain of Kamptee.	Do.	P. L.	410	13th January 1908.	Do.
Do.	(505) Mr. G. M. Prichard	Do.	P. L.	48	6th March 1908.	Do.
Do.	(506) Mr. J. Kellerschon.	Iron, manganese, tin, copper, bismuth and wolfram.	P. L.	151	26th February 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(507) The Central Provinces Prospecting Syndicate.	Manganese . .	M. L. .	1	10th February 1908.	30 years.
Do.	(508) Mr. Hiralal Sukul.	Do. . .	P. L. .	72	13th January 1908.	1 year.
Do. .	(509) Mr. Cooverji Bhoja	Do. . .	P. L. .	71	30th January 1908.	Do.
Do. .	(510) Do. do. .	Do. . .	P. L. .	785	17th January 1908.	Do.
Do.	(511) Mr. D. Laxminarain.	Do. . .	P. L. .	107	28th March 1908.	Do.
Do.	(512) Mr. Bapuji Vishwanath Gandhi.	Do. . .	P. L. .	14	4th March 1908.	Do.
Do.	(513) Messrs. B. B. B. Fouzdar & Bros.	Do. . .	P. L. .	114	3rd March 1908.	Do.
Do. .	(514) Messrs. Kassambhoy Ramji & Co.	Do. . .	P. L. .	171	6th March 1908.	Do.
Do. .	(515) The Central Provinces Prospecting Syndicate.	Do. . .	M. L. .	1	10th February 1908.	30 years.
Do. .	(516) Messrs. Jessop & Co. of Calcutta.	Do. . .	P. L. .	12	22nd January 1908.	1 year.
Do. .	(517) Messrs. Cursetji & Co.	Do. . .	P. L. .	24	3rd March 1908.	Do.
Do. .	(518) Mr. Shamji Madhoji.	Do. . .	P. L. .	60	28th March 1908.	Do.
Do. .	(519) Do. do. .	Do. . .	P. L. .	385	Do. .	Do.
Do. .	(520) Mr. M. Gupta .	Do. . .	P. L. .	26	9th March 1908.	Do.
Do. .	(521) Mr. Shamji Madhoji.	Do. . .	P. L. .	185	28th March 1908.	Do.
Do. .	(522) Mr. J. Kellerschon	Iron, manganese, tin, wolfram, bismuth and copper.	P. L. .	534	26th February 1908.	Do.
Do. .	(523) Lala B. Sitaram .	Manganese . .	P. L. .	40	28th March 1908.	Do.
Do. .	(524) Mr. Shamji Madhoji.	Do. . .	P. L. .	96	Do. .	Do.
Do. .	(525) Do. do. .	Do. . .	P. L. .	80	Do. .	Do.
Do. .	(526) Haji Sayed Gulam Mustaffa.	Do. . .	P. L. .	54	Do. .	Do.
Do. .	(527) Mr. J. J. Velloz .	Do. . .	P. L. .	134	29th February 1908.	Do.
Do. .	(528) Mr. J. Kellerschon	Do. . .	P. L. .	54	26th February 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(529) Messrs. Cursetji & Co.	Manganese . .	P. L. .	27	26th February 1908.	1 year.
Do. .	(530) Babu E. Nagannah Naidu.	Do. . .	P. L. .	19	4th March 1908.	Do.
Do. .	(531) Mr. Byramji Pestonji.	Do. . .	E. L. .	Entire village	26th February 1908.	Do.
Do. .	(532) Mr. Shamji Madhoji.	Do. . .	P. L. .	38	17th January 1908.	Do.
Do. .	(533) Messrs. Kassambhoy Ramji & Co.	Do. . .	E. L. .	Entire village	30th January 1908.	Do.
Do. .	(534) Do. do. .	Do. . .	E. L. .	64	6th March 1908.	Do.
Do. .	(535) Babu E. Nagannah Naidu.	Do. . .	E. L. .	52	3rd March 1908.	Do.
Do. .	(536) Messrs. B. B. B. Fouzdar & Bros.	Do. . .	P. L. .	175	Do. .	Do.
Do. .	(537) Mr. Govindj Rao Baji Rao.	Do. . .	E. L. .	301	17th January 1908.	Do.
Do. .	(538) Mr. Byramji D. Doongaji.	Do. . .	E. L. .	172	22nd January 1908.	Do.
Do. .	(539) Do. do. .	Do. . .	E. L. .	246	Do. .	Do.
Do. .	(540) Do. do. .	Do. . .	E. L. .	579	Do. .	Do.
Do. .	(541) Do. do. .	Do. . .	E. L. .	20	Do. .	Do.
Do. .	(542) Mr. Venkat Rao Naik.	Do. . .	E. L. .	1,084	17th January 1908.	Do.
Do. .	(543) Messrs. Ramprasad and Laxminarain.	Do. . .	P. L. .	121	9th March 1908.	Do.
Do. .	(544) Mr. M. B. Dadabhoy.	Do. . .	E. L. .	11	26th February 1908.	Do.
Do. .	(545) Mr. Madhulal Doogar.	Do. . .	P. L. .	1	9th June 1908	Do.
Do. .	(546) Mr. Cooverji Bhoja	Do. . .	P. L. .	26	6th April 1908	Do.
Do. .	(547) Do. do. .	Do. . .	P. L. .	113	Do. .	Do.
Do. .	(548) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	54	24th June 1908.	Do.
Do. .	(549) Mr. D. Laxminarain	Do. . .	P. L. .	630	25th May 1908	Do.
Do. .	(550) Do. do. .	Do. . .	P. L. .	45	Do. .	Do.
Do. .	(551) Do. do. .	Do. . .	P. L. .	23	Do. .	Do.
Do. .	(552) Messrs. Lall Behari Naraindas and Ramcharan Sanker Lall.	Do. . .	P. L. .	305	20th June 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(553) Messrs. Lall Behari Naraindas and Ramcharan Sankar Lall.	Manganese . .	P. L. .	7	4th March 1908.	1 year.
Do. .	(554) Messrs. Ramprasad and Laxminarain.	Do. . .	P. L. .	648	9th January 1908.	Do.
Do. .	(555) Mr. G. M. Prichard	Do. . .	E. L. .	1,472	9th June 1908	Do.
Do. .	(556) Mr. Madhulal Doogar.	Do. . .	P. L. .	701	Do. .	Do.
Do. .	(557) Do. do. .	Do. . .	P. L. .	451	Do. .	Do.
Do. .	(558) Mr. J. Kellerschon	Do. . .	P. L. .	166	18th May 1908 1908.	Do.
Do. .	(559) Mr. Madhulal Doogar.	Do. . .	P. L. .	17	9th June 1908	Do.
Do. .	(560) Mr. Cooverji Bhoja	Do. . .	P. L. .	333	29th June 1908.	Do.
Do.	(561) Mr. Hiralal Sukul .	Do. . .	P. L. .	250	16th April 1908.	Do.
Do. .	(562) Babu E. Nagannah Naidu.	Do. . .	P. L. .	24	29th June 1908.	Do.
Do. .	(563) Messrs. Kassambhoy Ramji & Co.	Do. . .	P. L. .	100	19th May 1908	Do.
Do. .	(564) Mr. Atmaram Antoba Kalar.	Do. . .	P. L. .	125	18th May 1908	Do.
Do. .	(565) Mr. Shamji Madhoji.	Do. . .	P. L. .	153	5th June 1908	Do.
Do. .	(566) Lala Mohanlal Kalar.	Do. . .	P. L. .	251	25th May 1908	Do.
Do. .	(567) Do. do. .	Do. . .	P. L. .	248	Do. .	Do.
Do. .	(568) Mr. Shamji Madhoji.	Do. . .	P. L. .	208	5th June 1908	Do.
Do. .	(569) The Indian Manganese Co.	Do. . .	P. L. .	138	15th May 1908	Do.
Do. .	(570) Messrs. Kassambhoy & Co.	Do. . .	P. L. .	83	19th May 1908	Do.
Do. .	(571) Babu E. Nagannah Naidu.	Do. . .	P. L. .	52	29th June 1908.	Do.
Do. .	(572) Mr. G. P. Jaideo Prasad.	Do. . .	P. L. .	30	2nd June 1908	Do.
Do. .	(573) Mr. Byramji Pestonji.	Do. . .	P. L. .	19	2nd May 1908	Do.
Do. .	(574) Do. do. .	Do. . .	E. L. .	2,710	2nd June 1908	Do.
Do. .	(575) Messrs. Kassambhoy Ramji & Co.	Do. . .	E. L. .	364	24th June 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(576) Mr. Darasha Mancherji.	Manganese . .	P. L. .	170	24th June 1908.	1 year.
Do. .	(577) Babu E. Nagannah Naidu.	Do. . .	P. L. .	57	29th June 1908.	Do.
Do. .	(578) Mr. B. V. Gandhi .	Do. . .	E. L. .	11	14th October 1907.	Do.
Do. .	(579) Messrs. Ramprasad and Laxminarain.	Do. . .	P. L. .	121	9th May 1908	Do.
Do. .	(580) Messrs. Kassambhoy Ramji & Co.	Do. . .	E. L. .	92	28th October 1907.	Do
Do. .	(581) Do. do. .	Do. . .	E. L. .	207	19th May 1908	Do.
Do. .	(582) Mr. Byramji Pestonji.	Do. . .	P. L. .	209	29th June 1908.	Do.
Do. .	(583) Mr. M. B. Dadabhoy.	Do. . .	P. L. .	38	24th June 1908.	Do.
Do. .	(584) Mr. T. B. Kantharia.	Do. . .	P. L. .	113	1st June 1908	Do.
Do. .	(585) Mr. Byramji D. Doongaji.	Do. . .	P. L. .	42	7th May 1908	Do.
Do. .	(586) Mr. Byramji Pestonji.	Do. . .	E. L. .	501	30th April 1908.	Do.
Do. .	(587) Mr. T. D. Zal .	Do. . .	P. L. .	49	21st November 1908.	Do.
Do. .	(588) Mr. T. B. Kantharia.	Do. . .	P. L. .	200	9th May 1908	Do.
Do. .	(589) Do. do. .	Do. . .	E. L. .	113	30th April 1908.	Do.
Do. .	(590) Lala Mohanlal Kalar.	Do. . .	P. L. .	251	2nd May 1908	Do.
Do. .	(591) Mr. Atmaram Antoba Kalar.	Do. . .	E. L. .	73	19th May 1908	Do.
Do. .	(592) Mr. T. D. Zal .	Do. . .	E. L. .	18	28th March 1908.	Do.
Do. .	(593) Mr. Byramji Pestonji.	Do. . .	E. L. .	Entire village	29th June 1908.	Do.
Do. .	(594) Do. do. .	Do. . .	E. L. .	Do.	Do. .	Do.
Do. .	(595) Do. do. .	Do. . .	E. L. .	Do.	Do. .	Do.
Do. .	(596) Do. do. .	Do. . .	E. L. .	Do.	Do. .	Do.
Do. .	(597) Do. do. .	Do. . .	E. L. .	Do.	Do. .	Do.
Do. .	(598) Do. do. .	Do. . .	E. L. .	Do.	Do. .	Do.
Do. .	(599) Do. do. .	Do. . .	E. L. .	Do.	Do. .	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(600) Mr. Byramji Pestonji.	Manganese . .	E. L. .	Entire village	29th June 1908.	1 year.
Do. .	(601) Do. do. .	Do. . .	E. L. .	Do.	2nd May 1908	Do.
Do. .	(602) The Mining Prospecting Syndicate.	Do. . .	E. L. .	522	8th June 1908	Do.
Do. .	(603) Mr. T. B. Kantharia.	Do. . .	E. L. .	96	30th April 1908.	Do
Do. .	(604) Messrs. Umaralli Brothers.	Do. . .	E. L. .	Entire village	24th April 1908.	Do.
Do. .	(605) Mr. Hiralal Sukul .	Do. . .	P. L. .	71	7th July 1908	Do.
Do. .	(606) Messrs. Kassambhoy Ramji & Co.	Do. . .	P. L. .	64	16th September 1908.	Do.
Do. .	(607) Mr. Cooverji Bhoja	Do. . .	P. L. .	534	9th July 1908	Do.
Do. .	(608) Mr. B. V. Kaorey .	Do. . .	P. L. .	31	5th August 1908.	Do.
Do. .	(609) The Nagpur Manganese Mining Syndicate.	Do. . .	P. L. .	139	Do. .	Do.
Do. .	(610) Mr. Lalbehari Naraindas.	Do. . .	P. L. .	246	17th July 1908	Do.
Do. .	(611) Mr. Hanmant Rao Mohitey.	Do. . .	P. L. .	0·28	Do. .	Do.
Do. .	(612) Mr. Atmaram Antoba Kalar.	Do. . .	P. L. .	21	21st January 1908.	Do.
Do. .	(613) Mr. Govindrao Deshmukh.	Do. . .	P. L. .	984	23rd September 1908.	Do.
Do. .	(614) Messrs. Ramprasad and Laxminarain.	Do. . .	P. L. .	215	Do. .	Do.
Do. .	(615) Mr. Byramji Pestonji.	Do. . .	P. L. .	60	2nd September 1908.	Do.
Do. .	(616) Mr. Byramji D. Doongaji.	Do. . .	P. L. .	22	23rd September 1908.	Do.
Do. .	(617) Mr. M. B. Dadabhoy.	Do. . .	P. L. .	37	16th September 1908.	Do.
Do. .	(618) Messrs. P. S. Kotwal and S. R. Naidu.	Do. . .	P. L. .	51	5th August 1908.	Do.
Do.	(619) Mr. Byramji Pestonji.	Do. . .	E. L. .	495	2nd September 1908.	Do.
Do. .	(620) Mr. Darashaw Mancherji.	Do. . .	P. L. .	157	21st September 1908.	Do.
Do. .	(621) Mr. T. B. Kantharia.	Do. . .	P. L. .	35	21st August 1908.	Do.
Do. .	(622) Do. do. .	Do. . .	P. L. .	889	21st July 1908	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(623) Mr. T. B. Kantharia.	Manganese . .	P. L. .	100	21st July 1908.	1 year.
Do. .	(624) Mr. Byramji D. Doongaji.	Mica . . .	P. L. .	12	17th August 1908.	Do.
Do. .	(625) Do. do. .	Manganese . .	P. L. .	172	3rd July 1908	Do.
Do. .	(626) Mr. Byramji Pestonji.	Manganese, wolfram, tin, etc.	P. L. .	227	2nd September 1908.	Do.
Do. .	(627) Do. do. .	Do. . .	E. L. .	Entire village	Do. .	Do.
Do. .	(628) Mr. Byramji D. Doongaji.	Manganese . .	P. L. .	246	7th August 1908.	Do.
Do. .	(629) Do. do. .	Do. . .	P. L. .	579	3rd July 1908	Do.
Do. .	(630) Do. do. .	Do. . .	P. L. .	20	Do. .	Do.
Do. .	(631) Mr. T. B. Kantharia.	Do. . .	P. L. .	140	24th August 1908.	Do.
Do. .	(632) Mr. Atmaram Antoba Kalar.	Do. . .	P. L. .	168	7th July 1908	Do.
Do. .	(633) Mir Aslam Khan .	Do. . .	P. L. .	59	24th August 1908.	Do.
Do. .	(634) The Central India Mining Co., Ltd.	Do. . .	P. L. .	139	16th September 1908.	Do.
Do. .	(635) Babu E. Nagannah Naidu.	Do. . .	P. L. .	32	21st August 1908.	Do.
Do. .	(636) Mr. Byramji D. Doongaji.	All minerals .	P. L. .	26	23rd September 1908.	Do.
Do. .	(637) Mr. Byramji Pestonji.	Manganese . .	P. L. .	Entire village	2nd September 1908.	Do.
Do. .	(638) Messrs. P. S. Kotwal and S. R. Naidu.	Wolfram, tin, and molybdenum.	E. L. .	153	17th July 1908	Do.
Do. .	(639) Mr. Hanmant Rao Mohitey.	Manganese . .	E. L. .	101	18th September 1908.	Do.
Do. .	(640) The Central Provinces Prospecting Syndicate.	Do. . .	P. L. .	33	24th November 1908.	Do.
Do. .	(641) Mr. R. H. Richardson.	Do. . .	P. L. .	84	4th November 1908.	Do.
Do. .	(642) The Central India Mining Co., Ltd.	Do. . .	M. L. .	25	12th October 1908.	30 years.
Do. .	(643) Mr. D. Laxminarain.	Do. . .	P. L. .	25	21st December 1908.	1 year.
Do. .	(644) Do. do. .	Do. . .	M. L. .	75	17th December 1908.	30 years.
Do. .	(645) Messrs. Kassambhoy Ramji & Co.	Do. . .	P. L. .	19	7th November 1908.	1 year.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(646) Babu Madhulal Doogar.	Manganese .	P. L. .	38	4th November 1908.	1 year.
Do. .	(647) Mr. G. P. Jaideo Prasad.	Do. . .	P. L. .	63	14th December 1908.	Do.
Do. .	(648) Mr. Atmaram Antoba Kalar.	Do. . .	P. L. .	73	Do.	Do.
Do. .	(649) Messrs. Kassambhoy Ramji & Co.	Do. . .	P. L. .	67	23rd December 1908.	Do.
Do. .	(650) Mr. Byramji Pestonji.	Do. . .	P. L. .	16	Do. .	Do.
Do. .	(651) Do. do. .	Do. . .	E. L. .	621	Do. .	Do.
Do. .	(652) Mr. Byramji D. Doongaji.	All minerals .	P. L. .	588	4th November 1908.	Do.
Do. .	(653) Mr. G. P. Jaideo Prasad.	Manganese . .	P. L. .	39	14th December 1908.	Do.
Do. .	(654) Mr. Byramji D. Doongaji.	Do. . .	P. L. .	7	4th November 1908.	Do.
Do. .	(655) Messrs. Kassambhoy Ramji & Co.	Do. . .	P. L. .	122	7th December 1908.	Do.
Do. .	(656) Mr. Byramji Pestonji.	Do. . .	P. L. .	35	20th December 1908.	Do.
Do. .	(657) Do. do. .	Do. . .	E. L. .	533	Do. .	Do.
Do. .	(658) Mr. Atmaram Antoba Kalar.	Do. . .	P. L. .	51	14th December 1908.	Do.
Do. .	(659) The Central India Mining Co., Ltd.	Do. . .	M. L. .	42	10th November 1908.	30 years.
Do. .	(660) Messrs. Kassambhoy Ramji & Co.	Do. . .	P. L. .	112	7th December 1908.	1 year.
Do. .	(661) Messrs. Martin & Co., Calcutta.	Molybdenum, iron, tin, wolfram and copper.	P. L. .	562	14th October 1908.	Do.
Do. .	(662) Mr. J. Kellerschon.	Molbydenum, iron, tin, wolfram, copper and manganese.	P. L. .	85	7th December 1908.	Do.
Do. .	(663) Mr. Byramji D. Doongaji.	Manganese . .	P. L. .	10	4th November 1908.	Do.
Do. .	(664) Mr. Darashaw Mancherji Dungaji.	Do. . .	P. L. .	98	Do. .	Do.
Do. .	(665) Messrs. P. S. Kotwal and S. R. Naidu.	Do. . .	P. L. .	250	24th November 1908.	Do.
Do. .	(666) Mr. M. B. Dadabhoy.	Do. . .	P. L. .	198	23rd December 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(667) Mr. D. Laxminarain.	Manganese . .	P. L. .	137	23rd December 1906.	1 year.
Do. .	(668) Mr. D. Gangadhar Rao.	Do. . .	P. L. .	302	24th April 1908.	Do.
Do. .	(669) Mr. Rambilas Murlidhar.	Do. . .	P. L. .	99	24th November 1908.	Do.
Do. .	(670) Mr. Byramji Pestonji.	Do. . .	P. L. .	37	23rd December 1908.	Do.
Do. .	(671) Babu E. Nagannah Naidu.	Do. . .	P. L. .	29	7th December 1908.	Do.
Do. .	(672) Messrs. Ramprasad and Laxminarain.	Do. . .	P. L. .	145	14th December 1908.	Do.
Do. .	(673) Mr. Byramji Pestonji.	Do. . .	E. L. .	Entire village	23rd December 1908.	Do.
Do. .	(674) Mr. Gopal Sheoram Dawe.	Do. . .	P. L. .	20	14th December 1908.	Do.
Do. .	(675) Mr. Byramji Pestonji.	Manganese, wolfram and copper.	E. L. .	762	23rd December 1908.	Do.
Do. .	(676) Do. do. .	Do. .	E. L. .	1,149	Do. .	Do.
Do. .	(677) Messrs. Lalbehari Narindas & Ramcharan Shankerlal.	Manganese . .	P. L. .	120	7th December 1908	Do.
Do. .	(678) Mr. Byramji Pestonji.	Do. . .	E. L. .	93	23rd December 1908.	Do.
Do. .	(679) Mr. Gopal Sheoram Dawe.	Do. . .	E. L. .	66	14th December 1908.	Do.
Do. .	(680) Messrs. R. K. Chullaney & Sons.	Do. . .	E. L. .	100	24th November 1908.	Do.
Do. .	(681) Mr. Byramji Pestonji.	Do. . .	E. L. .	365	23rd December 1908.	Do.
Do. .	(682) The Central Provinces Prospecting Syndicate.	Wolfram . .	E. L. .	4,802	7th December 1908.	Do.
Do. .	(683) Mr. Byramji Pestonji.	All minerals . .	E. L. .	2,120	23rd December 1908.	Do.
Do. .	(684) Do. do. .	Do. . .	E. L. .	2,203	Do. .	Do.
Do. .	(685) Do. do. .	Do. . .	E. L. .	148	Do. .	Do.
Do. .	(686) The Central India Mining Co., Ltd.	Manganese . .	P. L. .	167	14th October 1908.	Do.
Do. .	(687) The Nagpur Manganese Mining Syndicate.	Do. . .	E. L. .	85	7th December 1908.	Do.
Do. .	(688) Do. do. .	Do. . .	E. L. .	46	14th December 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(689) Mr. Byramji Pestonji.	Manganese .	E. L. .	275	7th December 1908.	1 year.
Raipur .	(690) Babu Batu Krishna Gupta of Bilaspur.	Graphite . .	E. L. .	1,355	23rd December 1908.	Do.
Saugor .	(691) Messrs. Kali Prasano Mukerji and Bhagwandas Sirvaya.	All minerals .	E. L. .	Not stated .	21st January 1908.	Do.
Do. .	(692) Messrs. Ganpat Rao Shrikhande, Gopal Rao and Ramkrishna Rao.	Do. . .	E. L. .	Do. .	23rd January 1908.	Do.
Do. .	(693) Mr. Azimullah Khan, Malguzar and Honorary Magistrate, Sa gor.	Do. . .	E. L. .	Do. .	13th January 1908.	Do.
Do. .	(694) Messrs. Dinanath B rolal and Laxman Rao.	Do. . .	E. L. .	33,151	20th January 1908.	Do.
Do. .	(695) Bhawani Shanker Sukul of Sa gor.	Do. . .	E. L. .	Not stated .	9th March 1908.	Do.
Do. .	(696) Messrs. Gour & Sons.	Do. . .	E. L. .	Do. .	11th March 1908.	Do.
Do. .	(697) Messrs. Kali Prasan Mukerji and Bhagwandas Sirvaya, Pleaders.	Do. . .	P. L. .	173 .	3rd April 1908	Do.
Do. .	(698) Mr. Damodar Ramchandra Shrikhande.	Do. . .	P. L. .	273	9th June 1908.	Do.
Do. .	(699) R. B. Seth, Ballabdass and Jiwandass.	Copper, iron, lead, etc.	P. L. .	180	23rd June 1908.	Do
Do. .	(700) Bhawani Shanker Sukul.	All minerals .	E. L. .	65,234	8th May 1908	Do.
Do. .	(701) Mahadeo Mukerji .	Do. . .	E. L. .	119,657	22nd May 1908	Do.
Do. .	(702) The Jubbulpore Prospecting Syndicate.	Iron, coal, copper, graphite and mineral oil.	P. L. .	150	14th July 1908	Do.
Do. .	(703) Messrs. Kali Prasano Mukerji and Bhagwandas, Pleaders, Saugor.	Iron, coal, copper, graphite, mineral oil, gold and silver.	P. L. .	179	2nd September 1908.	Do.
Do. .	(704) Ganpat Rao Shrikhande, retired Extra Assistant Commissioner, Gopal Rao and Ramkrishn Rao, Pleaders, Saugor.	Gold, silver, lead, copper, zinc, iron, talc, precious stones and mineral oil.	P. L. .	168	12th November 1908.	Do.
Seoni .	(705) Mr. Darasha Muncherji.	Manganese .	P. L. .	35	10th February 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Seoni	(706) Mr. Byramji Pestonji.	Manganese	P. L.	79	28th February 1908.	1 year.
Do.	(707) Dadu Vishwanath Singh of Seoni.	Do.	P. L.	60	8th February 1908.	Do.
Do.	(708) Do. do.	Do.	P. L.	117	Do.	Do.
Do.	(709) Messrs. Gauri Shankar and Dadu Bakhtawar Singh.	Do.	P. L.	191	Do.	Do.
Do.	(710) Do. do.	Do.	P. L.	363	Do.	Do.
Do.	(711) Mr. Wasudeo Trimbak.	Do.	P. L.	185	24th June 1908.	Do.
Do.	(712) Dr. Gaur and Messrs. Ratansha and Pestonji.	Do.	E. L.	2,684	9th April 1908	Do.
Do.	(713) Do. do.	Do.	E. L.	3,194	7th May 1908	Do.
Do.	(714) Do. do.	Do.	E. L.	640	Do.	Do.
Do.	(715) Mr. Rambilas Murlidhar.	Do.	P. L.	320	28th August 1908.	Do.
Do.	(716) Messrs. Kasambhoy, Gopaldass and Mahadeo Seth.	Mica	P. L.	750	29th September 1908.	Do.
Do.	(717) Do. do.	Do.	P. L.	368		
Do.	(718) Babu Kripashanker	Manganese	E. L.	1,012	6th August 1908.	Do.
Do.	(719) Mr. M. Billa	Manganese and wolfram.	E. L.	1,280	6th July 1908	Do.
Do.	(720) Mr. Kemji	Do.	E. L.	1,600	7th July 1908	Do.
Do.	(721) Do.	Do.	E. L.	1,280	Do.	Do.
Do.	(722) Do.	Do.	E. L.	1,920	Do.	Do.
Yeotmal	(723) Messrs. Parry & Co. of Madras.	Coal	M. L.	960	12th February 1908.	30 years.
Do.	(724) Do. do.	Do.	M. L.	1,280		
Do.	(725) Do. do.	Do.	M. L.	800		
Do.	(726) Do. do.	Do.	M. L.	800		
Do.	(727) Do. do.	Do.	M. L.	1,280		
Do.	(728) Do. do.	Do.	M. L.	1,280		
Do.	(729) Do. do.	Do.	P. L.	1,420	11th December 1908.	1 year.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

EASTERN BENGAL AND ASSAM.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chittagong .	(730) Messrs, Turner, Morrison & Co., Calcutta.	All minerals .	P. L. .	2,675	10th July 1908	Renewed for 1 year.
Garo Hills .	(731) The Hon'ble Mr. R. H. Henderson, C.I.E., Cachar.	Coal . . .	P. L. .	128,000	28th August 1908.	1 year.

MADRAS.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Anantapur .	(732) W. Stonor . .	Gold . . .	P. L. .	5,359	21st February 1908.	1 year.
Do. .	(733) W. Stonor, Agent, Anantapur Gold Fields, Ltd.	Do. . .	P. L. .	246	7th July 1908	Do.
Bellary .	(734) C. Jambon (since transferred to the General Sandur Mining Co.).	Manganese . .	M. L. .	44·25	15th June 1908.	30 years.
Do. .	(735) F. E. Dunn, Bangalore.	Do. . .	P. L. .	319·09	12th December 1908.	1 year.
Cuddapah .	(736) Ishak Ishmale & Co.	Gold, silver, copper, lead and mineral oil.	E. L. .	Not given .	9th January 1908.	Do.
Do. .	(737) Messrs. King and Josselyn, Madras.	Not stated . .	E. L. .	Do. .	3rd February 1908.	Do.
Do. .	(738) Sheik Meera Sahib & Co.	Manganese . .	E. L. .	11,520	October 1908	Do.
Do. .	(739) Devati Chenchia .	Mica . . .	E. L. .	640	1st December 1908.	Do.
Godavari .	(740) S. D. Ware . .	All minerals .	E. L. .	Not given .	10th March 1908.	Do.
Do. .	(741) F. H. Oakley .	Do. . .	E. L. .	Do. .	24th June 1908.	Do.
Do. .	(742) Mr. Bowden, on behalf of Mr. Oakley.	Graphite . .	P. L. .	2,560	Do. .	Do.
Do. .	(743) S. D. Ware . .	All minerals .	E. L. .	Not given .	20th October 1908.	Do.
Do. .	(744) Do. .	Do. . .	E. L. .	Do. .	Do. .	Do.
Do. .	(745) Mr. Bowden, on behalf of Mr. Oakley	Graphite . .	P. L. .	2,240	23rd December 1908.	Do.
Do. .	(746) Do. do. .	Do. . .	P. L. .	2,560	Do. .	Do.
Guntur .	(747) P. W. Bhose .	Iron ore . .	E. L. .	2,560	Not stated .	Do.
Do. .	(748) Mr. S. Craw Shaw .	Copper and precious stones.	P. L. .	29·72	Do. .	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

MADRAS—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kistna .	(749) The South Indian Coal Mining Syndicate.	All minerals .	E. L. .	In 124 villages	21st February 1908.	1 year.
Kurnool .	(750) A. Ghose . .	Steatite . .	P. L. .	161	15th October 1908.	Do.
Do. .	(751) R. C. Dyrianathan	Corundum . .	P. L. .	16·21	26th November 1908.	Do.
Nellore .	(752) I. Pattabhirami Reddi.	Mica . . .	P. L. .	19·80	9th March 1908.	Do.
Do. .	(753) K. Krishnaswami Mudali.	Do. . .	P. L. .	11·43	29th February 1908.	Do.
Do. .	(754) K. Ramakrisnayya Chetti.	All minerals .	E. L. .	All unoccupied reserved and unreserved lands.	29th January 1908.	Do.
Do. .	(755) K. Audinarayana Reddi.	Do. . .	E. L. .	Do. .	31st January 1908.	Do.
Do. .	(756) G. Venkatasubba Reddi.	Do. . .	E. L. .	Do. .	9th March 1908.	Do.
Do. .	(757) Muhammad Habibulla Sahib.	Do. . .	E. L. .	Do. .	10th March 1908.	Do.
Do. .	(758) K. Chinnia Venkatasubbaya Chetti.	Mica . . .	M. L. (patta land) .	2·70	14th February 1908.	20 years.
Do. .	(759) N. Narayana Raju .	Do. . .	M. L. .	75·53	27th November 1907.	30 years.
Do. .	(760) K. Guruswami Somayajulu.	Do. . .	P. L. .	19·96	20th January 1908.	1 year.
Do. .	(761) P. Venkataram Naidu.	Do. . .	P. L. .	17·50	31st January 1908.	6 months.
Do. .	(762) R. Lakshminarasa Reddi.	Do. . .	P. L. .	13·03	17th February 1908.	1 year.
Do. .	(763) N. Obula Reddi .	Do. . .	P. L. .	26·41	19th January 1908.	Do.
Do. .	(764) R. V. Kuppuswami Aiyar.	Do. . .	E. L. .	All reserved and unreserved unoccupied lands in Government villages.	6th January 1908.	Do.
Do. .	(765) A. Audinarayana Battudu.	Do. . .	E. L. .	Do. .	31st January 1908.	Do.
Do. .	(766) R. Venkata Reddi.	Do. . .	M. L. .	29·61	25th May 1908	30 years.
Do. .	(767) M. Varada Reddi .	Do. . .	M. L. .	4·46	30th December 1907.	3 years.
Do. .	(768) K. Panchalu Reddi	Do. . .	M. L. .	177·80	10th February 1908.	30 years.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(769) D. Panchala Naidu	Mica . . .	P. L. .	11·80	21st May 1908	1 year.
Do. .	(770) R. Rangaswami Rao.	Do. . .	M. L. . (extension)	135·90	4th March 1908.	30 years.
Do. .	(771) K. Krishnaswami Mudali.	Do. . .	P. L. .	10·1	7th May 1908	1 year.
Do. .	(772) R. Lakshminarasa Reddi.	Do. . .	M. L. .	57·45	28th June 1908.	30 years.
Do. .	(773) B. Chenchuramiah	Do. . .	P. L. .	19·90	23rd June 1908	1 year.
Do. .	(774) George Ellgen .	All minerals .	E. L. .	Not stated .	4th May 1908	Do.
Do. .	(775) R. Rangaswami Rao.	Mica . . .	P. L. . (renewal)	10	10th May 1908	Do.
Do. .	(776) K. Panchalu Reddi	All minerals .	E. L. .	Not stated .	27th May 1908	Do.
Do. .	(777) S. V. Subba Rao .	Do. . .	E. L. .	Do. .	23rd June 1908	Do.
Do. .	(778) K. Panchalu Reddi	Mica . .	P. L. . (converted to M. L.)	144·50	23rd July 1908	30 years.
Do. .	(779) P. Venkatarama Nayudu.	Do. . .	M. L. . (extension)	80·44	11th September 1908.	Do.
Do. .	(780) Muhammad Asad-uddin Ahmad Sahib.	Do. . .	M. L. .	49·57	4th August 1908.	20 years.
Do. .	(781) R. V. Kuppuswami Aiyar.	Do. . .	M. L. . (extension)	31·86	20th September 1908.	30 years.
Do. .	(782) G. Venkatasubba Reddi.	Do. . .	M. L. .	194·37	3rd July 1908	Do.
Do. .	(783) K. Panchalu Reddi	Do. . .	M. L. .	37·50	16th July 1908	Do.
Do. .	(784) A. Audinarayana Battudu.	Do. . .	P. L. .	11·20	11th July 1908	1 year.
Do. .	(785) P. Venkatarama Nayudu.	Do. . .	P. L. .	15·75	20th September 1908.	Do.
Do. .	(786) B. Chenchuramiah	All minerals .	E. L. .	Not stated .	4th September 1908.	Do.
Do. .	(787) Haji Muhammad Habibulla Sahib.	Mica . . .	P. L. .	11·40	14th September 1908.	Do.
Do. .	(788) Do. do. .	Do. . .	P. L. .	14·21	2nd December 1908.	Do.
North Arcot	(789) Messrs. King and Josselyn for Mrs. Puddephat.	All minerals .	E. L. .	Whole district	April 1908 .	Do.
Do. .	(790) Ishak Ismail & Co.	Do. . .	E. L. .	Do. .	Do. .	Do.
Do. .	(791) Chinnatambi Raju Pernambet.	Do. . .	E. L. .	Do. .	Do. .	Do.
Salem .	(792) James Short .	Iron ore . .	P. L. .	4,369·28	17th June 1908.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

MADRAS—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Salem	(793) K. M. Velasami Chetti.	Mica	E. L.	Unassessed and assessed waste lands in Edapadi, Omalur and Jalakandapuram villages.	2nd September 1908.	1 year.
Do.	(794) A. T. Tiruvengadasami Mudaliyar.	Corundum	E. L.	Assessed and unassessed waste lands in the whole district.	17th August 1908.	Do.
Do.	(795) T. R. Venkataraman Aiyar.	Mica	E. L.	Do.	11th September 1908.	Do.
Do.	(796) James Short	Gold, galena, ilmenite, barytes, pyrites and other metallic ores.	P. L.	475	14th December 1908.	Do.
Do.	(797) Do.	Magnesite and chromite.	P. L.	1,705·09	10th March 1908.	Do.
Do.	(798) Leon Tardival	Do.	P. L.	631·90	12th October 1908.	Do.
South Canara	(799) S. E. Rego	Gold and silver	P. L.	82	10th July 1908	Do.
Trichinopoly	(800) T. Leishman	Wolframite, tantalum and other allied minerals.	P. L.	370	8th May 1908	Do.
Do.	(801) T. R. Tawker & Sons.	Plumbago, copper and other metallic ores.	P. L.	572·40	20th October 1908.	Do.

NORTH-WEST FRONTIER PROVINCE.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Abbottabad.	(802)* Rai Sahib Sardar Rocha Ram & Sons, Contractors, Abbottabad.	Coal	P. L.	240	*20th January 1908.	1 year.

PUNJAB.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Attock	(803) Lieutenant M. Snee, retired Sub-Engineer (M. W. S.) of Port Haney, British Columbia.	Gold	P. L.	53,760	13th November 1908.	5 years.

* This license was granted in 1907.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

PUNJAB—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum	(804) Lala Thakar Das	Coal	P. L.	283·51	14th February 1908.	1 year.
Do.	(805) Ishar Das, Contractor, Pind Dadan Khan.	Do.	P. L.	141	30th May 1908	Do.
Do.	(806) L. Dala Shah and Karam Chand of Dalwal.	Do.	P. L.	150	27th May 1908	Do.
Do.	(807) Do. do.	Do.	P. L.	200	Do.	Do.
Do.	(808) The Punjab Coal Co.	Do.	M. L.	1,171	20th December 1905.	30 years.
Mianwali	(809) S. Lachman Singh	Do.	P. L.	54	4th April 1908	1 year.
Do.	(810) Bindra Ban, son of late Lala Thakar Das.	Do.	P. L.	1,548	29th September 1908.	Do.
Do.	(811) Do. do.	Do.	P. L.	1,575	23rd October 1908.	Do.
Shahpur	(812) Malik Mohan Singh	Do.	P. L.	1,635	10th March 1908.	Do.
Do.	(813) Sujan Singh of Hadali.	Do.	P. L.	363	29th October 1908.	Do.

UNITED PROVINCES.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Almora	(814) Sawai Singhai Kheur Chand, Lakhmi Chand and Abdur Rahim Khan.	Copper ore	P. L.	40	Not stated	1 year.
Garhwal	(815) Mr. R. M. Nash	Do.	M. L.	1,010	1st October 1908.	30 years.
Jhansi	(816) Srish Chander Roy, on behalf of the Prospecting Syndicate, Jubbulpore.	Copper, lead, silver and gold.	P. L.	3·62	1st July 1908	1 year.

SUMMARY.

Provinces.	Prospecting licenses.	Exploring licenses.	Mining leases.	Total of each Province.
Baluchistan	2	..	20	22
Bengal	20	..	3	23
Bombay	47	45	..	92
Burma	47	15	2	64
Central Provinces	347	151	30	528
Eastern Bengal and Assam	2	..	..	2
Madras	30	26	14	70
North-West Frontier Province	1	..	..	1
Punjab	10	..	1	11
United Provinces	2	..	1	3
Total for each kind and Grand Total, 1908	**508**	**237**	**71**	**816**
Totals for 1907	*368*	*171*	*61*	*600*

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CLASSIFICATION OF LICENSES AND LEASES.

TABLE 10.—*Prospecting and Mining Licenses granted in Baluchistan during 1908.*

DISTRICT.	1908.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Quetta-Pishin	1	160	Coal.
Sibi	1	910	Chromite.
TOTAL .	2	..	
Mining Leases.			
Quetta-Pishin	2	260	Chromite.
Do.	8	543·95	Coal.
Zhob	10	2,510·826	Chromite.
TOTAL .	20	..	

TABLE 11.—*Prospecting and Mining Licenses granted in Bengal during 1908.*

Prospecting Licenses.

District	No.	Area in acres	Mineral
Darjeeling	1	*97	Coal, copper, iron and other ores.
Hazaribagh	14	2,320	Mica.
Singbhum	4	4,588	Manganese.
Do.	1	1,920	Chromite.
TOTAL .	20	..	

Mining Leases.

District	No.	Area in acres	Mineral
Gaya		469	Mica.

TABLE 12.—*Prospecting Licenses granted in Bombay during 1908.*

DISTRICT.	1908.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Belgaum	1	410	Manganese.
Bijapur	1	1,992	Gold.
Do.	4	2,241	Manganese.
Do.	1	608	Coal.
Do.	1	1,436	Asbestos.
Dhárwár	2	288	Copper and lead.
Do.	2	1,647	Manganese.
Do.	4	5,754	Gold.
Do.	1	1,347	Gold, silver and other metals.
Do.	1	378	Gold and copper.
Do.	1	808	Lead.
Kánara	1	2,481	Copper.
Do.	16	41,722	Manganese.
Do.	1	2,037	Manganese and mica.
Pánch Mahals	7	4,012	Manganese.
Do.	2	Not stated.	Do.
Ratnagiri	1	10	Graphite.
TOTAL	47	..	

TABLE 13.—*Prospecting and Mining Licenses granted in Burma during 1908.*

Prospecting Licenses.

Amherst	309·14	Antimony.
Bhamo	3,200	Gold, silver, lead and tin
Henzada	5,760	Coal.
Kyaukse	1,280	All minerals.
Magwe	20,660·03	Petroleum.

TABLE 13. *Prospecting and Mining Licenses granted in Burma during 1908.*

Prospecting Licenses—*contd.*

DISTRICT.	1908. No.	1908. Area in acres.	1908. Mineral.
Mandalay	1	484·8	All minerals.
Do.	1	1,280	Silver, lead, zinc and copper.
Do.	1	68·83	Iron ore.
Mergui	1	960	Tin and wolfram.
Minbu	1	1,600	Petroleum.
Do.	2	Not stated.	Do.
Myingyan	1	3,200	Coal and mica.
Do.	7	23,429	Petroleum.
Northern Shan States . .	2	2,560	Gold.
Do.	2	4,800	Silver and lead.
Do.	1	2,880	Antimony, tin, silver and allied metals.
Do.	1	1,920	Copper and associated minerals.
Pakokku	2	2,785	Petroleum.
Prome	1	6,400	Gold and tin.
Southern Shan States . .	2	6,400	Silver, lead and associated minerals.
Do.	1	160	Gold and silver.
Thaton	1	2,560	Silver and lead.
Thayetmyo	3	8,320	Petroleum.
Toungoo	1	3,200	All metals.
Yamethin	1	4,960	Gold, silver, lead, copper and tin.
TOTAL .	47	..	

Mining Leases.

DISTRICT.	No.	Area in acres.	Mineral.
Mongmit State	1	5,760	Gold.
Pakokku [1]	1	640	Petroleum.
TOTAL .	2	..	

TABLE 14.—*Prospecting and Mining Licenses granted in the Central Provinces during 1908.*

DISTRICT.	1908.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Balaghat	69	13,243	Manganese.
Do.	4	715	Mica.
Do.	1	8,639	Bauxite.
Betul	5	55,508	Coal.
Do.	1	1,283	Graphite and corundum
Do.	1	298	All minerals.
Bhandara	68	9,095	Manganese.
Do.	1	2,730	All minerals.
Chanda	2	252	Copper.
Chhindwara	28	6,776	Manganese.
Do.	6	14,551	Coal.
Do.	2	249	Mica.
Drug	1	84	Platinum, wolfram, tin, etc.
Jubbulpore	5	1,090	Manganese.
Do.	2	144	Iron and manganese.
Do.	2	1,338	Bauxite.
Do.	3	3,600	Gold, silver, copper, lead, etc
Nagpur	121	17,452·28	Manganese.
Do.	3	912	Iron, manganese, wolfram, tin, etc.
Do.	1	12	Mica.
Do.	2	647	Molybdenum, wolfram, tin, etc.
Do.	2	614	All minerals.
Saugor	2	416	Do.
Do.	1	677	Iron, coal, copper, gold, silver, etc.
Seoni	8	1,350	Manganese.
Do.	2	1,118	Mica.
Yeotmal	1	1,420	Coal.
TOTAL	347	..	

TABLE 14.—*Prospecting and Mining Licenses granted in the Central Provinces during 1908*—contd.

District.	1908.		
	No.	Area in acres.	Mineral.
Mining Leases.			
Balaghat	8	1,449	Manganese.
Bhandara	6	585	Do.
Chhindwara	2	125	Do.
Do.	1	2,607	Coal.
Jubbulpore	1	289	Steatite, talc and asbestos.
Do.	1	35	Gold, silver, lead and copper.
Nagpur	5	144	Manganese.
Yeotmal	6	6,400	Coal.
TOTAL	30	..	

TABLE 15.—*Prospecting Licenses granted in Eastern Bengal and Assam during 1908.*

Prospecting Licenses.

District	No.	Area in acres.	Mineral.
Chittagong	1	2,675	All minerals.
Garo Hills	1	128,000	Coal.
TOTAL	2	..	

TABLE 16.—*Prospecting and Mining Licenses granted in Madras during 1908.*

Prospecting Licenses.

District	No.	Area in acres.	Mineral.
Anantapur	2	5,605	Gold.
Bellary	1	319·09	Manganese.
Godavari	3	7,360	Graphite.
Guntur	1	29·72	Copper and precious stones.
Kurnool	1	161	Steatite.

TABLE 16.—*Prospecting and Mining licenses granted in Madras during 1908*—contd.

DISTRICT.	1908.		
	No.	Area in acres.	Mineral.
Prospecting Licenses—*contd.*			
Kurnool	1	16·21	Corundum
Nellore	14	221·49	Mica.
Salem	1	4,369·28	Iron ore.
Do.	1	475	All minerals
Do.	2	2,336·99	Magnesite and chromite.
South Canara	1	82	Gold and silver.
Trichinopoly	1	370	Wolfram, tantalum, etc.
Do.	1	572·40	Plumbago, copper and other metallic ores
TOTAL	30	..	
Mining Leases.			
Bellary	1	44·25	Manganese.
Nellore	13	1,021·59	Mica.
TOTAL	14	..	

TABLE 17.—*Prospecting Licenses granted in the North-West Frontier Province during 1908.*

Prospecting Licenses.

Abbottabad		240	Coal.

TABLE 18.—*Prospecting and Mining Licenses granted in the Punjab during 1908.*

Prospecting Licenses.

Attock	1	53,760	Gold.
Jhelum	4	774·51	Coal.
Mianwali	3	3,177	Do.
Shahpur	2	1,998	Do.
TOTAL	10	..	

TABLE 18.—*Prospecting and Mining Licenses granted in the Punjab during 1908*—contd.

DISTRICT.	1908.		
	No.	Area in acres.	Mineral.
Mining Leases.			
Jhelum	1	1,171	Coal.

TABLE 19.—*Prospecting and Mining Licenses granted in the United Provinces during 1908.*

Prospecting Licenses.

District	No.	Area in acres	Mineral
Almora	1	40	Copper ore.
Jhansi	1	3·62	Copper, lead, silver and gold.
	2	..	

Mining Leases.

District	No.	Area in acres	Mineral
Garhwal	1	1,910	Copper ore.

TABLE 20.—*Summary of Concessions granted in Government lands during the ten years 1899 to 1908.*

YEAR.	Mining and Prospecting Licenses.	Exploring Licenses.	Total.
1899	47	13	60
1900	61	11	72
1901	89	15	104
1902	89	16	105
1903	84	16	100
1904	125	26	151
1905	145	44	189
1906	211	41	252
1907	539	61	600
1908	579	237	816

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Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts. Siwalik carnivora. Siwalik group of Sub-Himalayan region. South Rewah Gondwana basin. Ferruginous beds associated with basaltic rocks of north-eastern Ulster, in relation to Indian laterite. Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on lower trias of Himalayas.' Mammalian fossils from Perim Island.

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" " " " 2 (1880). Gastropoda and supplement to pt. 1, pp. 111 (73—183), pls. 10 (1 double), (vii—xvi).

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" " " " 6 (1886). Cœlenterata, pp. 90 (835—924), pls. 20 (xcvii—cxvi).

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" " " " " 2 (1891), pp. 89—242, pls. 8 (*out of print*).

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[illegible] ervations made on a visit to Chaderkul, Thia[illegible] glaciers within Kangra district. Building and or[illegible] India. [illegible] for iron manufacture in Raniganj coal-field. M[illegible]rdha coal-field.

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Part 2.] 1909. [October

ON THE OCCURRENCE OF *Ostrea latimarginata*, A CHARACTERISTIC GÁJ SPECIES, IN THE "YENANGYAUNG STAGE" OF BURMA.

BY E. VREDENBURG, A.R.S.M., A.R.C.S., F.G.S., *Assistant Superintendent, Geological Survey of India,* AND M. STUART, B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.*

I.—Ostrea latimarginata.

(BY E. VREDENBURG.)

WE are indebted to Mr. H. J. Davies, Geologist to the Burma Oil Company, for one of the most interesting fossil discoveries as yet made in Burma. Amongst some fossils sent by Mr. Davies from the Pyalo-Kwetha anticline in the Allanmyo subdivision of the Thayetmyo district, there are several shells of an oyster which shows the specific characters of *Ostrea latimarginata*, one of the principal zone fossils of the uppermost horizons of the Gáj in Western India. The characters and horizons of this shell have been discussed in a previous volume of these *Records* (Vol. XXXVI, pp. 317—318) and there is a good illustration by J. de C. Sowerby in the Transactions of the Geological Society, series 2, Volume V, Pl. XXV (1840), under the name *O. flabellula*. The specimen figured by Sowerby is from Kachh. The shell has been obtained from Kachh, Kathiawar, and Sind at the uppermost limit of the Gáj beds. The fixed valve is ornamented with narrow ribs, close-set and numerous, but with a tendency sometimes to become obsolete; its most conspicuous character is the enormous flange-shaped surface that surrounds the body-cavity and extends far

Sitsayan shales and the locally unfossiliferous or poorly fossiliferous lower part of the sandstone, while the fossiliferous beds of Theobald's Prome series have been united with the Kama clays to constitute the Yenangyaung series,[1] thus relying on a purely accidental and local character to split up the well-marked unit constituted by the great sandstone mass.

The discovery of such a characteristic zone fossil as *Ostea latimarginata* at a definite horizon makes it expedient to return to Theobald's more natural classification. This form occurs at the upper limit of the Prome beds as originally defined, that is, just below the base of the Kama clay. Since *Ostrea latimarginata* is particularly characteristic of the upper zones of the Gáj in Western India we have, by analogy, the Prome series, as originally defined, coinciding with the Gáj and probably an undetermined portion of the Nari, while the Kama clay must be the equivalent of a portion of the Hingláj beds as defined by Mr. Vredenburg. The Kama clay, where originally observed and defined by Theobald, was not measured by him. According to Mr. Vredenburg in the Mekran province of Baluchistan, the Gáj proper is overlaid by a clay and sandstone formation several thousand feet thick which has been distinguished as the Hingláj series. Where most typically developed as in the Hingláj mountains and their neighbourhood, the lower part of the Hingláj series consists principally of clay, while the upper part includes a vast thickness of sandstones passing upwards into conglomerates. The stratigraphical succession and lithology suggest a close similarity to the Kama clay and the overlying Irrawaddy system.

According to Mr. Vredenburg the Hingláj series in its lower beds contains fossils closely related to the Gáj fauna, while the uppermost beds contain a decidedly different assemblage of forms, one of the leading shells being *Pecten Vasseli* Fuchs. In Burma also many of the fossils form the Upper Prome beds (=Lower Yenangyaung=Gáj) pass into the Kama clay, while a marine fauna, which has not yet been examined in detail, occurs locally in the overlying beds of the Irrawaddy system.

The Irrawaddy system, on the strength of its mammalian fauna, has been regarded as the equivalent of the Siwaliks. Mr. Vredenburg is of opinion that even the newest Hingláj beds are older than

[1] *Pal. Indica*, New series, Vol. I, part 3.

the Siwaliks proper. It is quite possible that the Irrawaddy system contains representatives both of the Upper Hingláj and of the Siwaliks. The stratigraphical studies so far undertaken are quite insufficient to settle the mutual relations of the beds with marine fossils and those with mammalian remains within the Irrawaddy system. Nor do we know whether any stratigraphical break occurs between the mammalian beds and the supposed equivalents of the Upper Hingláj. A distinct unconformity separates the Kama clay from the basement beds of the Irrawaddy system with marine fossils in Lower Burma, but the stratigraphical break is not accompanied by any great change in the fauna and may not therefore represent a great interval of time. Nevertheless the recognition of this unconformity is of great importance in accounting for the extreme divergences in the thickness of the Kama clay that have been observed from place to place: there are many instances where the Kama clay expands from a few feet to more than 1,200 feet in thickness within the distance of a few miles, bringing the succession into the closest correspondence with the vast thickness of supra-Gáj clays mentioned by Mr. Vredenburg. This inconstancy of the Kama clay is a feature that has been brought to light only by the recent survey and was unknown to Dr. Noetling. The ignorance of this fact coupled with his not altogether happy re-adjustment of Theobald's scheme of classification has led him to a misconception which is of rather serious import from the practical point of view; at Yenangyaung the beds overlying the petroliferous horizon were regarded by Noetling as representing the entire mass of his Yenangyaung stage, that is Theobald's Kama clay and Upper Prome beds. Consequently the petroliferous beds themselves were referred by Noetling to his Prome stage proper, that is Theobald's Lower Prome beds and Sitsayan shales, and it has been an accepted idea ever since that these lower beds (Noetling's Promean) constitute the true petroliferous horizon in the Pegu group.

The detailed studies made in the neighbourhood of another petroliferous locality, Padaukpin, have shown that the petroliferous sands are mere intercalations within the Kama clay, which at that place, in consequence of the irregularities depending upon the abovementioned unconformity, has expanded to a thickness of considerably more than 1,200 feet. In the light of the observations made at Padaukpin and other places, it becomes extremely probable

that the petroliferous beds at Yenangyaung are also intercalations in the Kama clay.

In every instance where the petroliferous horizon in the Pegu system can be definitely identified, it is invariably the Kama clays and their subsidiary sandstones that hold the oil, a fact which should be constantly kept in mind in any further search for oil-bearing localities.

CHINA-CLAY AND FIRE-CLAY DEPOSITS IN THE RAJMAHAL HILLS. BY MURRAY STUART, B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 1, 2 and 3, fig. 1.)

INTRODUCTION.

DURING the latter part of the season 1907-08, I was deputed to the Rajmahal Hills to investigate the district for kaolin and fire-clay as well as for sand for glass-making purposes. The results of my enquiries into the latter subject I have embodied in a separate report.[1] The area investigated is that described by Ball in the Memoirs of the Geological Survey of India, Volume XIII, part 2.

China-clay has long been known to exist in the Rajmahal Hills at Lohandia (25° 3′, 87° 27′) and Pátarghatta (25° 20′, 87° 20′) and is mentioned by V Ball.[2] Since 1902 china-clay has been worked at Mangal Hat (25° 4′, 87° 51′) where it exists in the white Damuda sandstone, and is now being used by the Calcutta Pottery Company for the manufacture of their china and porcelain. Besides these three localities china-clay had not been noted in the district, and no further information was known about fire-clay beyond the fact that it existed in the district.[3]

CHINA-CLAY.

As the result of my investigations I find that china-clay occurs in three ways in the district :—

(*a*) As the decomposition product of felspar in the fundamental gneisses and schists.

(*b*) In the white Damuda sandstone, where its presence is due to the decomposition of felspar originally present in the sandstone.

(*c*) As beds of white china-clay interbedded in the white Damuda sandstone.

[1] *Records, Geol. Surv. Ind.*, XXXVII, p. 101.
[2] *Memoirs, Geol. Surv. Ind.* Vol. XIII, p. 86.
[3] *Memoirs, Geol. Surv. Ind.*, Vol. XIII, p. 87.

The first form (*a*) is seen in quantity in the undermentioned localities :—

Katangi near Baskia (24 °28′, 87° 29′) (21, 195).[1]
Karanpur (24° 19′, 87° 27′) (21, 193).
Dodháni (24° 17′, 87° 27′) (21, 194).
Base of hill Pátarghatta (25° 20′, 87° 20′) (21, 205).
In nala near Rajabhita (25° 57′, 87° 27′ 30″) (21, 179).
Bhukhanda (24° 21′, 87° 24′) (21, 207).
Near Bagmara on the Pir Painti-Dumka road (24° 37′, 87° 21′) (21, 206).

Of these the most important are the three first-mentioned localities. The china-clay there is quite white and very free from quartz and other mechanical impurities. It is of the powdery, not very plastic, variety and much resembles the Cornish china-clay in physical properties. I made an analysis of the sample obtained at Dodháni with the following result :—

Silica . . .	54·5	per cent.
Alumina . .	39·6	,,
Water by difference	5·9	,,

As some of the silica is present as free quartz, this analysis indicates material not unlike Cornish china-clay, which has the composition :—

Silica .	46·4	per cent.
Alumina	39·7	,,
Water	13·9	,,

To test the refractoriness of these china-clays I made small bricks from them which I subjected to a white heat (about 1,600° Fahr.) for a quarter of an hour. In none of the cases was there any sign of fusion, so that these china-clays should prove suitable for the manufacture of all kinds of white porcelain and china-ware. The drawbacks they possess are their low plasticity and their limited occurrence. The low plasticity need not be a disqualifying condition, as the same obtains with the well-known Cornish china-clays.

The quantity of china-clay in these localities, however, cannot be estimated from the surface indications, and to get any real idea as to its extent trial shafts must be sunk. The exposure of china-clay which is seen at Katangi is some 50 yards in length, and is seen to a depth of 15

[1] The numbers in brackets refer to the index numbers of specimens preserved in the Museum of the Geological Survey of India.

feet without any base being exposed; and, without actual quarrying, it is impossible to say how much will be available.

The china-clay seen at Dodháni is much less, although no limits of depth or extent are seen. It is worked by the natives by means of tunnels, and they use it to form a whitewash. The tunnels go down to a depth of 10 feet into the clay and show no bottom. They extend some 30 feet across the strike of the gneiss, and there are indications that the china-clay stretches some distance along the particular bands of gneiss. The outcrop of these china-clay beds and the surrounding country is covered and concealed by some 5 feet of soil and alluvium.

The exposure at Karanpur is confined to two small sinkings in which the china-clay becomes less pure below a depth of 6 feet. Here too the china-clay appears to extend a short way under the overlying alluvium along the strike of the gneiss which is in a south-easterly direction.

The exposure at Pátarghatta is seen at the base of the hill facing the river. Here the percentage of quartz grains present is considerably higher than in the former cases, and the extent of the china-clay-bearing gneiss cannot be seen. There is, however, evidence of the wide extent of these beds under the Pátarghatta hill which renders them so far the most important in the district. In 1860 a large pottery works flourished there, managed by Mr. G. Macdonald. I have appended an abstract of his report on these pottery works and a report on the geology of the hills by H. F. Blanford. This was printed in 1864 and contains very valuable and detailed information as to the extent and value of the clays which cannot now be otherwise obtained except by fresh borings and experiments.

The other exposures mentioned above are very small in extent and are of scientific interest only.

As regards transport, Katangi is some five miles distant from Narganjo and is connected with it by a rough cart track. From Narganjo a good road runs to Muraroi Station on the East Indian Railway some 40 miles distant. Karanpur and Dodháni are respectively about 40 and 35 miles from Rampur Hat Station on the East Indian Railway, and are connected with it by a good road.

The second form (*b*) in which china-clay occurs is in the white Damuda sandstone of the district. Its presence there is almost entirely due to the decomposition of felspar originally present in the sandstone; though there is occasional evidence, as at Amjhari (24° 31′, 87° 29′) (21, 199) that the china-clay was deposited as such together with the coarse gritty sandstone. In this case it would be derived

from the fundamental gneisses and schists where they had already become kaolinised. Occasionally also the sandstone contains inclusions of china-clay. These inclusions range in size from quite small fragments, up to many cubic inches in volume (21, 185). Their presence in the rock is due to a change in the conditions of deposition, and the consequent cutting out of some of the contemporaneous beds of china-clay which occur interbedded with the sandstone, the fragments from the clay bed being subsequently re-deposited as inclusions in sand.

This china-clay is being extracted from the sandstone at Mangal Hat by a system of crushing, washing and subsequent settling, and is being used by the Calcutta Pottery Company for the manufacture of their wares. In an article upon Porcelain by Mr. Satya Sundar Deb, Scholar in Ceramics in Japan,[1] this china-clay from the sandstone at Mangal Hat is mentioned and the following statement made : "The total and rational analyses are very satisfactory and the clay is not in any way inferior to German or Japanese kaolins." In addition to this Mr. Deb informed me that this china-clay is exceedingly plastic and does not need such a high temperature in firing as the foreign less plastic china-clays. This form of china-clay occurs throughout the white Damuda sandstone of the district, and may be found wherever the white sandstone occurs. It is perhaps most conveniently obtained at Mangal Hat owing to the close proximity of the railway, but it occurs equally well throughout the Hura Coal-field (21, 181; 21, 182; 21, 183; 21, 184; 21, 185), in the northern and eastern boundaries of the Dhamni Coal-field (21, 178; 21, 202), and in parts of the Chuperbhita Coal-field, chiefly near Alobaru (24° 32′, 87° 32′) (21, 180), Chilgo (24° 34′, 87° 30′ 20″) and Amjhari (24° 31′, 87° 29′) (21, 199).

In many places on the western side of the hills the percentage of china-clay present in the sandstone is much higher than it is at Mangal Hat or Pir Pahar (25° 6′, 87° 50′), a group of hills adjacent to Mangal Hat. However, on the western side of the hills the white Damuda sandstone is often slightly micaceous, which would mean greater care in the washing of the china-clay, while at Mangal Hat the sandstone is remarkably free from mica.

The third form (*c*) occurs at Pátarghatta (25° 20′, 87° 20′) and in the Hura Coal-field. At Pátarghatta the china-clays occur some 20 feet above the fundamental gneiss and persist throughout the Pátarghatta hills (21, 201; 21, 202). These clays are fully described by

[1] *Industrial India*, vol. II, No. 4, p. 95.

Mr. Macdonald and Mr. Blanford in the appended report, and from my observations I can say that their quantity is practically undiminished and that they yield a very white, quite infusible china.

In the Hura Coal-field china-clay occurs as a bed from 4 to 5 feet thick about a quarter of a mile to the west of Piáram (25° 0′, 87° 27′) (21, 198) and also at a place just south of the streams by Hura on the jungle road leading to Mahua Batháu. This seam also is about 3 feet thick (21, 196).

In addition to the above there occurs in the centre of the aqueduct, south of Rohri village, a seam of a harder variety of china-clay, but this is only 10 inches in thickness. It must be crushed before it can be used, and yields a nearly white china. These seams all dip gently to the east at an angle varying between 5 and 10 degrees, and are about a mile from any cart road. It is, therefore, doubtful whether the difficulties of transport would allow of their profitable quarrying, though it is almost certain that they extend over a large area. The nearest railway station would be Pir Painti on the East Indian Railway which is some 31 miles away.

I analysed a sample of china-clay taken from the bed near Piáram. The anhydrous material contained :—

Silica	59·5	per cent.
Alumina	39·4	,,
Alkalies and loss	1·1	,,

SUMMARY.

China-clay occurs plentifully throughout the district, and there exist two localities which have yielded supplies to successful works. At Mangal Hat the Damuda sandstone is now yielding china-clay which is being used by the Calcutta Pottery Works. The most important deposits however seem to be those at Pátarghatta where successful works flourished in 1860. These deposits are fully described by Messrs. Macdonald and Blanford. The works are mentioned by the late Dr. V. Ball,[1] but the reason for their ceasing work was not lack of demand of the articles manufactured there, as he states, but owing to the departure of Mr. Macdonald for private reasons. When in full work, these works produced articles of the highest quality, including table china, porcelain for scientific purposes, the finest Parian ware, etc., equal to that

[1] *Memoirs, Geol. Surv. Ind.*, Vol. XIII, p. 86.

produced in Staffordshire. Many of these were exhibited in Calcutta in the Exhibition in 1864, and were for some time preserved in the Asiatic Society. The success of the works was due to Mr. Macdonald who had expert knowledge of the industry. Coal was obtained from a mine at Lohandia, where Mr. Macdonald sunk a shaft.

When Mr. Macdonald left these works in 1864 they were closed and fell into disuse; but the materials and the coal remain, and under the management of an expert should again produce articles quite equal to the best produced in Staffordshire. Mr. Macdonald considered that Pátarghatta was the best situated place for a works in India; and from my own observations, I can certainly say that the position as regards materials is excellent, that their supply is practically speaking unlimited, and that if the best wares could be manufactured there over 40 years ago they can be manufactured now.

FIRE-CLAY.

Fire-clay occurs somewhat plentifully on the western side of the Rajmahal hills. It is found mostly in the three northern coalfields where it occurs in beds in the Damuda rocks. These beds are nowhere of any great thickness and are generally about 3 feet thick. They all dip at low angles towards the east, the dips ranging from about 5 to 10 degrees.

The clays themselves vary in colour from white to purple and blue, and yield bricks which range from dirty-white, fine-textured ware to yellow bricks almost identical in appearance to the best Stourbridge bricks.

In order to test the fire-clays I made small bricks from them, and subjected these when dry to a white heat (about 1,600° Fahr.) for a quarter of an hour in a blowpipe furnace. By this means I was able to test both the plasticity and the refractoriness of the clay.

With reference to the following table of fire-clay beds, it should be remarked that a few of the beds have strictly speaking no right to be included in a list of the fire-clay deposits of the district. But in cases where the appearance of the clay might lead one to hope for good results or in cases where a poor clay exists close to a good fire-clay, I have thought it desirable to enumerate them in the table.

From the results of my experiments on the samples of clay which I obtained, I am of the opinion that the fire-clay which occurs in the Rajmahal hills will answer most if not all of the requirements for which Stourbridge clay is at present used in this country. Many of the clays enumerated in the following table are perfectly infusible, and their tex-

ture is quite as fine and uniform as that of the finest Stourbridge clay and therefore I see no reason why these clays should not make such articles as retorts for gas manufacture, etc., as well as the simpler fire-bricks.

In addition to these high quality fire-clays, there are many which are equally infusible, but which have perhaps not a sufficiently fine texture to be suitable for the manufacture of retorts, etc. These would make fire-bricks which should be quite as satisfactory as bricks made from the finest fire-clays.

Index to Localities.

Locality.	Latitude.	Longitude.
Alobaru	24° 32′	87° 32′
Amjhari	24° 31′	87° 29′
Bagmara	24° 37′	87° 21′
Bargo	24° 30′ 40″	87° 27′
Bhulgora	24° 57′	87° 27′
Bora ghat	25° 1	87° 25′
Burari	24° 57′ 20″	87° 27′ 30″
Chilgo	24° 34′	87° 30′ 20″
Dhumni	24° 47′ 30″	87° 33′
Dumabhita	24° 42′	87° 32′ 40″
Gilhurria	24° 50′ 40″	87° 28′
Gugri	24° 44′	87° 31′
Hura	24° 58′ 30″	87° 26′
Jiajore	24° 45′ 50″	87° 28′
Khijuria	24° 15′	87° 18′
Lohandia	25° 3′	87° 25′
Narganjo	24° 25′	87° 28′
Rohri	24° 58′ 30″	87° 26′ 30″
Salduha	24° 19′	87° 34′
Simlong bungalow	24° 45′	87° 30′
Simru bungalow	25° 2′	87° 23′
Simru ghat	25° 1′	87° 23′
Simra or Samru village	25° 4′ 30″	87° 24′
Surwa	24° 26′	87° 32′
Surwa north of Katikund	24° 23′	87° 28′
Telbhita	24° 47′ 20″	87° 28′
Umbápáni	24° 16′ 30″	87° 35′

List of fire-clay beds in the Rajmahal

Locality.	Number of Specimen.	Colour of clay.	Plasticity.
North base of hills south-east of Simru bungalow.	21—231	Dirty white .	Good . .
50 feet below 21—231	21—212	Do. .	Do. .
Base of hills Bora Ghat, north entrance . .	21—208	Do. .	Do. . .
Base of hills ½ mile west of 21—208 . .	21—250	Do. .	Do. . .
In Simru Ghat	21—220	Do. .	Do. . .
South-west of hill south of Lohundia . .	21—232	Do. .	Do. . .
Base of west of hill south of Lohundia . .	21—253	Do. .	Do. . .
West base of Bhuskapahar, ½ mile north of Simru village	21—211	Blue . .	Do. . .
South of Rohri in aqueduct	21—234	Dirty white .	Do. . .
East side of hill west of Rohri . . .	21—252	Do. .	Do. . .
Hura, by stream	21—224	Do. .	Do. . .
Hura, below 21—224	21—242	Purple . .	Do. . .
Nala west of Burari on road	21—235	Pale yellow .	Do. . .
In nala south of Bhulgora	21—205	Purple . .	Do. . .
Gilhurria	21—219	Blue . .	Do. . .
North-east end of Dhumni Coalfield . .	21—256	Purple . .	Do. . .
Hill above Dhumni	21—204	Grey . .	Do. . .
Base of hill, below 21—204	21—240	Blue . .	Do. . .
Continuation of 21—240 on main hills to north.	21—216	Do. . .	Do. . .
Second bed 3 feet below 21—216 . . .	21—217	Do. . .	Do. . .
West of small hill east of Simlong bungalow .	21—221	Yellow white .	Do. . .
½ mile east of Jiajore	21—237	Dirty white .	Do. . .
South of Telbhita in nala	21—233	Do. .	Do. . .
½ mile down stream below 21—233 . .	21—215	Grey . .	Do. . .

hills or Dáman-i-koh.

Thickness of bed.	Refractoriness.	Colour after firing.	REMARKS.
3 feet . .	Infusible .	Grey . .	Should make a good fire-clay.
2 feet seen base invisible.	Indication of vitrification.	Dirty yellow .	Only useful as a common fire-clay; would not be suitable for very high temperatures.
Ditto .	Infusible .	Grey . .	Shows a few grains of mechanically mixed iron after firing, but should make a good ordinary fire-clay.
4 feet . .	Do. .	Pale yellow .	Should make a good fire-clay.
2 feet seen base invisible.	Do. .	Nearly white .	Slightly gritty, but should make a good ordinary fire-clay.
3 feet seen base invisible.	Do. .	Blue white .	Should make an excellent fire-clay.
Ditto .	Do. .	Pale yellow .	Ditto ditto.
2 feet seen base invisible.	Vitrifies slightly	Dark brown .	Only useful as a common fire-clay; would not be suitable for very high temperatures.
2 feet 9 inches .	Infusible .	Dirty white .	Should make a good fire-clay.
4 feet seen base invisible.	Do. .	Nearly white	Should make an excellent fire-clay.
2 feet 6 inches .	Do. .	Pale yellow .	Should make a very good fire-clay.
3 feet 3 inches .	Fusible . .	Brown . .	Useless.
2 feet 6 inches .	Infusible .	Pale yellow .	Should make a good fire-clay.
8 feet . .	Vitrifies slightly	Grey . .	Only useful as a common fire-clay, would not be suitable for very high temperatures.
3 feet . .	Infusible .	Light brown .	Should make a good fire-clay.
3 feet seen base invisible.	Vitrifies slightly	Dark brown .	Only useful as a common fire-clay: would not be suitable for very high temperatures.
3 feet 6 inches .	Infusible .	Grey . .	Should make a good fire-clay or cheap china-clay.
3 feet 9 inches .	Vitrifies slightly	Yellow . .	Only useful as a common fire-clay; would not be suitable for very high temperatures.
4 feet . .	Infusible .	Dark yellow .	Should make a good fire-clay.
3 feet . .	Vitrifies slightly	Pale yellow .	Only useful as a very common fire-clay: would not be suitable for very high temperatures.
2 feet 3 inches	Infusible .	Light yellow .	Shows a few grains of mechanically mixed iron after firing, but should make a good ordinary fire-clay.
2 feet seen base invisible.	Vitrifies slightly	Light brown .	Only useful as a common fire-clay: would not be suitable for very high temperatures.
4 feet . .	Do. .	Grey . .	Ditto ditto.
3 feet . .	Infusible .	Do. . .	Slightly gritty, but should make a good ordinary fire-clay.

List of fire-clay beds in the Rajmahal

Locality.	Number of Specimen.	Colour of clay.	Plasticity.
Doomabhita	21—225	White . .	Good . .
In bend of stream west of Jiajore . . .	21—218	Yellow white .	Do. . .
South base of hill east of Simlong . . .	21—247	Dirty white .	Do. . .
South-east of hill near Dhumni on Simlong road.	21—222	Blue . .	Do. . .
In nala west of Googri above coal seam . .	21—251	Dirty white .	Do. . .
¾ mile south of Simlong on Heranpoor road .	21—248	Do. .	Do. . .
In nala ¼ mile south of 21—251 . .	21—220	White . .	Do. . .
Near Bargo	21—258	Dirty white .	Do. .
Underlying 21—258	21—214	Purple . .	Do. . .
Chilgo	21—223	White . .	Do. . .
North of Surwa	21—213	Do. . .	Do. . .
Sarwa, north of Katikund	21—209	Dirty white .	Do. . .
East of Narganjo in nala	21—249	Do. .	Do. . .
South of Salduha in nala	21—257	Do. .	Do. . .
Umbarpanee	21—211	Yellow . .	Do. . .
Khijuria	20—211	Grey . .	Do. . .

APPENDIX.

Report on the Geology of Patraghatta Hill, near Colgong, by Henry F. Blanford, A.R.S.M., with Analyses of Clays by G. Macdonald.

[From pamphlet printed by Savielle and Collier, Cossitollah, 1864, for distribution at the Exhibition of 1864.]

The two isolated hills of Patraghatta and Kasdeh are situated on the banks of the Ganges a few miles below Colgong, and rise from the nearly level alluvial country (which forms the greater part of the Bhagulpore district) to the height of about 180 and 400 feet, respectively. The latter hill is by far the larger, covering an area of nearly one square mile as measured on the geological map. Mr. Macdonald considers that this is much below its real extent. It is of irregular form, and this may account for the discrepancy, and is distant about three-quarters of a mile from a smaller hill of Patraghatta, which rises abruptly on the verge of the river, and covers an area of not more than one-fifth of a square mile. Though

hills of Dáman-i-koh—contd.

Thickness of bed.	Refractoriness.	Colour after firing.	REMARKS.
4 feet . .	Infusible .	Dirty yellow .	An impure clay, but should make a common fire-clay.
4 feet . .	Do. .	Light yellow .	Should make an excellent fire-clay.
8 feet . .	Vitrifies slightly	Light grey .	Not suitable for very high temparatures, but should make a common fire-clay or china-clay.
3 feet 9 inches .	Do.	Dirty white .	Include fused particles after firing due to grains of iron, therefore useless.
4 feet . .	Infusible .	Nearly white .	Should make an excellent fire-clay.
2 feet seen base invisible.	Do. . .	Light yellow .	Ditto.
4 feet . .	Do. . .	Dirty white .	Slightly impure, should make a good fire-clay.
1 foot . .	Do . .	Yellow . .	Should make an excellent fire-clay.
2 feet . .	Do. . .	Light yellow .	Ditto.
3 feet seen base invisible.	Vitrifies slightly	Dark grey .	Only useful as a very common fire-clay; would not be suitable for very high temperatures.
10 to 15 feet .	Do. . .	Brown . .	Ditto ditto.
3 feet .	Infusible .	Light brown .	Slightly gritty, but should make a good ordinary fire-clay.
1 foot 6 inches .	Vitrifies slightly	Grey . .	Only useful as a common fire-clay; would not be suitable for very high temperatures.
4 feet . .	Do. .	Brown . .	Ditto. ditto.
3 feet . .	Do. .	Grey . .	Ditto. ditto.
6 feet seen base invisible.	Do. .	Dark grey .	Ditto. ditto.

thus disconnected, they are identical in geological structure, and have undoubtedly at some former time been continuous with each other and with the rocks now forming the Rajmahal hills to the eastward.

Kasdeh hill is still covered with thick jungle, and although a few native excavations have been made on certain parts of it for the extraction of clay, the rocks of which it is composed have not been nearly so thoroughly exposed as has been the case at the hill of Patraghatta, where most of the jungle has been cleared, and a large number of excavations and borings enable the structure of the hill to be ascertained in considerable detail. Accordingly, during my late visit to Patraghatta I devoted the greater part of the time at my disposal to a close examination of the hill of Patraghatta, with a view to determine the extent of its clays suitable for the manufacture of pottery, and having thus obtained a pretty thorough knowledge of its formation, I paid a brief visit to Kasdeh hill, in order to satisfy myself of its general character and the probability of its being equally rich in useful minerals with the former, in proportion to its extent. The present report will, therefore, be chiefly devoted to a description of the smaller or Patraghatta hill. The Kasdeh hill may be examined in detail at some future time, and I would recommend this

be done before any extensive workings are opened out upon it. At present, although much detailed information might be gained in three or four days devoted exclusively to this hill, I do not think that until more trial works have been made upon it, its structure can be made out with that detail which is desirable for economical purposes. To the general facts of its resemblance in structure to Patraghatta hill and of its containing several extensive beds of excellent clays, I am, however, enabled to speak with confidence.

The basis rock of the Bhaugulpore district, as of India generally, is of the class termed metamorphic by Geologists, which varies infinitely in mineral composition but consists mainly of quartz with felspar, mica, hornblende and garnet in varying proportion. Most of the hills of the Bhaugulpore district are formed by elevated bases of these rocks which protrude through the general alluvial covering of the surrounding plain. The rocks and hills of Colgong and Gungelday are, for example, of this character, but except for building purposes the stone is generally valueless. At the base of Patraghatta hill, and on the south-western spur of Kasdeh hill up to a height of about 100 or 150 feet, rocks of this class also appear. They were here originally composed of quartz, felspar and a little mica, but owing to some peculiarity in the chemical composition of the second mineral, which appears to preponderate in the rock, it has been decomposed very extensively, and the whole of the rock has been resolved into a friable granular mass, which can be generally dug out with a shovel. This is closely similar to the cornish-stone of English potters, and in its original state may be used to a considerable extent in certain kinds of pottery.

When levigated, the fine white clay which results from the decomposition of the felspar, is separated under the name of kaolin or china-clay, and is one of the most valuable materials used in the manufacture of pottery and porcelain. At the south-western corner of Patraghatta hill, this rock is seen up to a height of about 25 feet above the present level of the river, but at the spot it is less thoroughly decomposed than in the shafts which have been sunk below the level of the alluvium. At the north-western corner of the same hill it has been sunk into a depth of 14 feet, and in a boring near the lime-kilns at the foot of the south flank of the hill, it has been penetrated, as I am informed by Mr. Macdonald, to a depth of 40 feet. It is, therefore, in all probability, continuous beneath the hill, and as at the depth of 40 feet it was found to be equally decomposed as nearer the surface, there is no reason to believe that this depth represents the limit of its extent downwards.

At Kasdeh hill, where, as mentioned, it rises to a height of about 100 feet above the plain, the material appeared to be equally good with that of Patraghatta. It is not at all improbable that it extends widely beneath this hill also, as well as in all probability, beneath the alluvium intervening between the two hills. I have no hesitation, therefore, in saying that so far as present evidence enables me to judge, the supply of kaolin obtainable is very large indeed—what would be termed by some inexhaustible,—but this would of course be an incorrect phraseology. The kaolin is very white, and apparently free from iron.

The mass of both Kasdeh and Patraghatta hills consists of rocks of a very different character to the above, but which yield materials not less valuable for the manufacture of pottery. These are stratified deposits, the materials of which have been originally derived from the metamorphic rocks, but having been sorted and arranged by the action of water, are now deposited in alternate layers of

sandy clays, and clay free from the admixture of sand. A general section of Patraghatta hill hereto prefixed will best explain their mode of occurrence.

The total thickness of these beds, as existing in Patraghatta hill, is about 180 feet, and they are capped by a little outline of volcanic rocks, the last remnant of an outpouring which must at one time have extended widely over the country.

The beds have a general inclination of 4° or 5° to the eastward, and individual layers or beds do not appear to be continuous throughout but gradually to thin out and be replaced by those of another character, so that a section measured at one place would not at all accurately represent that which would be obtained at the distance even of a few hundred yards. Notwithstanding this irregularity, the *general* character of the beds appears to be the same throughout the hill, so that although any given bed may not be traceable (as a rule) more than a few hundred yards, a shaft sunk at any part of the hill would expose layers of clay, sand, etc., of similar character in much the same relative proportion, though differing in sequence. In the excavations now exposed I have been able to measure one nearly perfect and two or three partial sections, which will give the total thickness of the beds, and at the same time enable a fair idea to be formed of the amount of valuable minerals existing in the hill. These I will now describe :—

Section 1 is taken at the north-western corner of the hill. A shaft is in process of sinking at this point near the river bank, and for the first 30 feet passes through the lower beds of the stratified series. It then enters the decomposed gneiss, 14 feet of which have been already sunk through. The cornish-stone from this shaft yields an excellent kaolin. Above the shaft the rocks are well seen or the face of the hill to within about 30 feet of the summit, and five beds of clay, varying in thickness from 2 feet 6 inches to 6 feet in thickness, are exposed, all well fitted for the manufacture of Pottery. These are not, however, the only useful materials : many of the sands are scarcely less valuable for mixture with the clay, consisting for the most part of nearly pure quartzose sand, free from iron, and very white, when washed. The highest bed, included in this section, is a hard flaggy ferruginous sandstone, containing probably not less than 30 to 35 per cent. of iron. This band appears to be continuous through the hill and serves as an excellent horizon from which to measure sections elsewhere. It is seen forming the roof of a little cave on the north brow of the hill, and is again met with in the shaft (Section 3), and on the southern face of the hill above the spot where a boring is now in progress (Section 2).

About fifty yards to the south of Section 1, a couple of trial excavations in the lower part of the face of the hill expose the Section No. 4. If this be compared with the lower part of Section 1, it will be seen that, although the general relations of the beds are similar, their relative thickness is very different, and some thin beds appear which do not occur in Section 1. This affords a fair illustration of the variability of the stratification within a short distance. The proportion of valuable materials is here somewhat greater than in Section 1. The clays are excellent, especially those in the upper excavation, and are either pure white pipe-clay, or a brownish grey clay, which, being apparently colored by organic matter, only burns white.

Section No. 5 represents the lowest beds, where they rest on the gneiss at the south-western corner of the hill, and, therefore, nearly a quarter of a mile distant from No. 1. The gneiss beneath them (here about 25 feet above the river level)

is less decomposed than in the bottom of the shaft at No. 1, but is still sufficiently so to be of some value if required.

Section No. 6 comes next in order, passing round to the south of the hill. It is taken in two quarries behind the workshops, and exhibits two beds of white clay, 6 feet and 5 feet 6 inches in thickness, respectively: I am uncertian what part of Section No. 1 this section represents. Behind the kilns, and a little way up the side of the hill, a bore hole has been sunk through, as Mr. Macdonald informs me, 82 feet of clays and sands before reaching the gneiss, 40 feet of which have also been penetrated. According to the section recorded by Mr. Macdonald, one 12 feet bed of white clay and one 13 feet bed of dark clay were met with in the bore hole, besides several beds of sandy clay. The kaolin from the gneiss at the bottom was of excellent quality through the whole thickness penetrated, *viz.*, 40 feet.

Further along the same face of the hill, and about half way up it, a bore hole is now being sunk. The bore has reached a depth of 21 feet, 19 of which Mr. Macdonald informs me are through clay. I am inclined to doubt whether much of this bed is such as can be profitably employed in pottery, but I saw a specimen brought up by the borer from the bottom equal to any clay I met with elsewhere. From this bore hole the sequence of the beds up to the iron band is given in Section 2.

It is exposed partly in a cutting, partly on the natural surface of the ground.

The beds above the iron band are only exposed in the shaft on the eastern summit of the hill, and are 65 feet in thickness up to the basalt. I was unable to descend this shaft, but give the section on Mr. Macdonald's authority without details. No. 3. — I saw some specimens of excellent clay among the little heaps from the shaft.

Adding together the Section No. 1 and No. 3, the total thickness of the stratified rocks up to the basalt is 180 feet. I think it may be fairly assumed that this is not above the real average, and it is not improbable, judging from the depth of the bore hole behind the kilns, that the beds may be thicker on the south side of the hill. Confining myself, however, to the results of my own observation, I will take 180 feet as the average thickness, and two-ninths of the whole or 40 feet, will be (according to the average of the sections measured by myself) the amount of fine clay fit for pottery which they include. I take no count of the beds between the iron band and the basalt, *i.e.*, they are not included in the calculation of the average, but are included in the application of that average, inasmuch as I have not been able to examine them personally, and I equally exclude from consideration the results of the borings, as the sections have not been noted in such a way as to admit of comparison with my own observations. In the above estimate I have also excluded all the sandy clays, many of which would be valuable for other purposes, such as the manufacture of fire bricks, and the sands which will be as useful in pottery as the clays themselves. Thus, then, although the fine clays occur for the most part in beds of 3 and 4 feet only, it frequently happens that in excavating these a considerable thickness of beds might be profitably worked together, the materials being sorted as removed.

It thus appears that of the materials required for the manufacture of pottery, all of those most largely employed are obtainable in one hill, *viz.*, cornish-stone, kaolin, sand and pipe-clays as also clays for the manufacture of fire brick. All these exist in large quantity in the hills of Patraghatta, and apparently also in that of Kasdeh. Moreover, I have little doubt that they extend beneath the flat ground

intervening between the two hills, and it is probable that they would equally be met with in shafts sunk anywhere to the east or south-east of the former hill, within half a mile or so of its foot.

Of other materials, Mr. Macdonald showed me some excellent felspar from Lohunda, about 20 miles distant, whence a good coal is also obtainable for the furnaces. Sufficient lime for the use of the works may yet be obtained also from the hill, but as the limestone is a mere surface formation unconnected with the essential structure of the hill, the supply is very limited, and could not be calculated upon anywhere in the neighbourhood. Borax, potash, gypsum, and a few other materials used in pottery, such as *zaffre* and other coloring materials, must be purchased, but this is the case at almost all pottery works, and their carriage would be inexpensive in proportion to their intrinsic value. Gypsum is known to occur in the North-Western Provinces and the Punjab, and may probably at some future time be procurable from Indian localities at less cost than that which is now brought from Europe.

Finally, I consider that large pottery works may be established at Patraghatta without any fear of the failure of clays, sands or other materials that I have mentioned.

HENRY F. BLANFORD.

The 8th November 1863.

Analysis of samples of clay by G. Macdonald, Esq.

Analysis of the Patraghatta clays and sand.	Loss by ignition in water and organic matter.	Silica.	Alumina.	Lime.	Magnesia.	Iron and Manganese.	Soda, Potash and Loss.
No. 1.—Kaslin	14·00	57·00	39·11	1·42	1·21	Trace	1·26
No. 2.—Fine white clay, closely resembling kaolin . .	10·00	55·00	40·38	2·20	1·32	Trace	1·00
No. 3.—A fine light drab-colored clay	12·75	51·00	46·30	1·56	0·50	0·22	0·12
No. 4.—A light drab clay . .	15·50	54·53	40·27	2·00	1·25	0·75	1·20
No. 5.—A fine light drab clay .	10·25	63·15	35·20	0·75	0·36	0·44	0·10
No. 6.—A light brown clay . .	0·00	70·00	27·10	Not ascertained.			
No. 7.—Decomposed gneiss . .	5·25	78·00	18·50	0·45	1·47	0·00	1·58
No. 8.—Washed sand	0·25	96·00	1·15	Trace	Trace	Trace	2·85
No. 9.—A fine light drab clay, from 43 feet deep in bore, seam 13 feet thick . .	10·00	62·00	31·00	Not ascertained.			
No. 10.—A drab clay, from 44 feet in bore, near the kilns, excellent fire-clay . .	8·00	80·00	16·00	Not ascertained.			

All the analyses were made from 100 parts of the ignited clay, and the loss by ignition in water and organic matter recorded, the clays having first been dried at 212° Fahr.

In Nos. 6, 9, and 10, the full analyses are not given, their value being most important from the quantity of silica they contain in a fine state of division, and they are sufficiently free from iron and lime to be most valuable for the manufacture of fire-bricks, fire-clay, and stone-ware.

List of articles forwarded to the Exhibition of 1864.

Specimens of clays referred to in the report, numbered according to their respective analyses.

Three milk pans of sizes forming a set.

Specimens of various articles of table service, such as plates, dishes, cups, saucers, beakers, jugs, etc.

Drain-pipes comprising glazed specimens of two nine-inch and two six-inch pipes.

Unglazed specimens of various kinds of roofing tiles.

EXPLANATION OF PLATES.

Plate 1.—Ideal section of Pátarghatta Hill by H. F. Blanford.

Plate 2.—Sections of borings in Pátarghatta Hill by H. F. Blanford.

Plate 3, fig. 1.—Photograph of a 3-ft. white clay bed in Damuda white sandstone, Bora ghat.



THE OCCURRENCE OF COAL AT GILHURRIA IN THE RAJMAHAL HILLS. BY MURRAY STUART, B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 3, fig. 2.)

IN the early part of 1908 whilst I was examining the western flank of the Rajmahal hills for china-clay and sand for glass manufacture, I was informed that coal was being obtained from a place called Gilhurria (24° 50′ 40″, 87° 28″), situated nearly half way between the boundaries of the Hura and Dhamni coalfields.

On visiting the locality I found that the coal was exposed in the bed of the stream, which was then dry, and that it was being worked by the natives some few yards up the face of the hill south of the stream course.

It is being worked by means of quarrying and the following section is seen :—

Upper quarry :

	Ft.
Soil	1
Red sand	4
Carbonaceous, blue clay	2
Blue clay	3
Coal-seam (base not seen)	6

underneath which is a second quarry showing :

Carbonaceous, white kaolinitic grit	4
Coal-seam (base not seen)	3

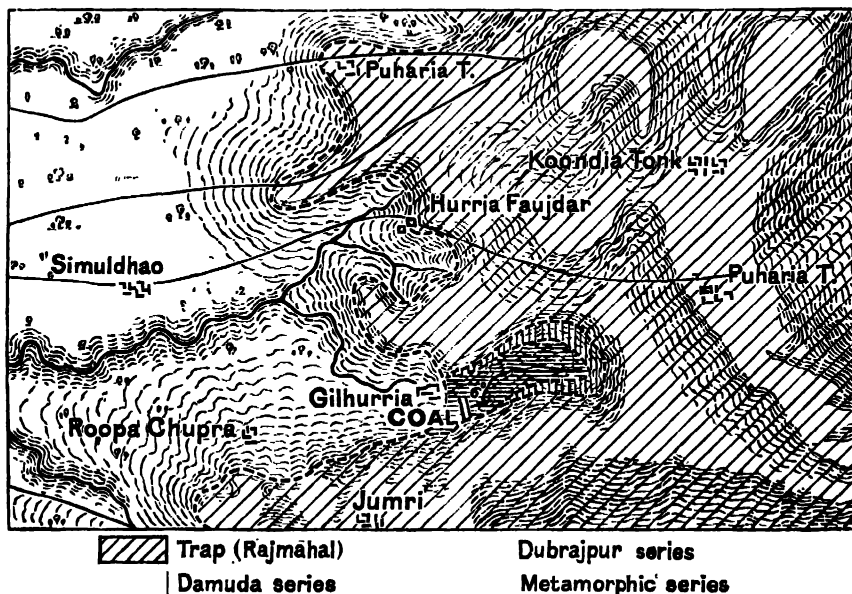
The two quarries are separated by 14 ft. of undergrowth and scree.

The strike of the rocks is N. 10° W. with an easterly dip of 6°.

The examination of the rocks surrounding the exposed coal revealed the outcrop of a small patch of Damuda rocks, hitherto unsuspected, in the valley near Gilhurria covered directly with trap at the western end, but passing up into a thin covering of Dubrajpur sandstones to the east.

The whole outcrop is very small but is interesting inasmuch as it contains burnable coal and also that it indicates the continuity of the Hura and Dhamni Coalfields under the trap. In the map of the district prepared by V. Ball and published in *Memoirs, Geological Survey*

of India, Vol. XIII, part 2, these rocks are all mapped as Dubrajpur rocks and the continuity of the two coalfields, underneath the trap, was only a matter of conjecture.



Geological sketch-map of the country around Gilhurria. (Scale 1″=1 mile.)

The coal itself is of a very uniform quality in both seams. In texture it is of the carbonaceous shale variety, but it is crowded with small fragments of ca bonised wood and plant remains which give to it its burning power (21, 260).

Although these fragments all lie in a definite direction, yet there is an absence of any banding o bedding in the coal. In this respect it differs from a true coal.

An analysis of the coal, made by me, showed it to have the following composition —

Moisture .	7·46	per cent.
Volatile matter	30·94	„
Fixed carbon .	39·67	„
Ash . .	21·93	„

Since these figures are obtained from the coal where it outcrops it is probable that the percentage of volatile matter in the coal would be found to be higher some little distance underground. That is, the percentage of combustible matter in the coal would be higher. In the case of a true coal, whose composition remains practically constant over large tracts, this would be so. But in this case it is impossible to predict whether the composition of the coal does persist over any distance or whether it constantly changes.

EXPLANATION OF PLATE.

Coal mine at Gilhurria—

(*a*) Red sand—4 ft.
(*b*) Carbonaceous blue clay—2 ft.
(*c*) Blue fire-clay—3 ft.
(*d*) Coal-seam—6 ft. (base not seen).

NOTE ON A PEGU INLIER AT ONDWE, MAGWE DISTRICT, UPPER BURMA. BY E. H. PASCOE, M.A., B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 4 and 5.)

THE following note has been prepared from a report by M. R. Ry. Sethu Rama Rau, Sub-Assistant, Geological Survey of India, Burma Oilfields party, resulting from his survey of sheet 156, Burma Survey 1-inch map, during April 1909: both the accompanying maps (Plates 4 and 5) are the work of the same observer.

Position.—The inlier, as shown on the map (Plate 4), occurs on the Yin Chaung (chaung=stream or stream-bed), some 10 miles east of the Irrawaddy, and includes the village of Ondwe (Lat. 20° 6′ 52″, Long. 95° 10′ 45″), which is about 16 miles by road from Magwe. The centre of the inlier is some 30 miles S.S.E. of the Yenangyaung Oilfield.

Structure.—In the midst of the Irrawaddy Sandstone ("Pliocene" of earlier publications), the Pegu beds ("Miocene") form an elliptical outcrop 4 miles long and 1½ miles broad, at the centre of a symmetrical anticlinal dome (see map, Plate X). The direction of its longer axis, which may be taken as coincident with the anticlinal axis, is about 40° W. of N. to 40° E. of S.

The fold is a very gentle one: a transverse section across its centre would show the following dips:—

(*i*) at the Pegu-Irrawaddy boundary on either side, 10°—12°,
(*ii*) 2,000 feet from this boundary, nearer the crestal area, from 3° to 5°.

A few minor dip-faults occur, one of which was traced for ¼ mile, but Mr. Sethu Rama Rau reports them to be too small to affect any possible oilfield.

Rocks.—The Pegu rocks are described as consisting "chiefly of shales and friable sandstones, with thin sandy limestone bands": they are evidently softer than the Irrawaddy sandstones as they have suffered greater denudation. Here and there the limestone bands are fossiliferous, and one fossil band is traceable on both sides of the crest. Selenite is abundant.

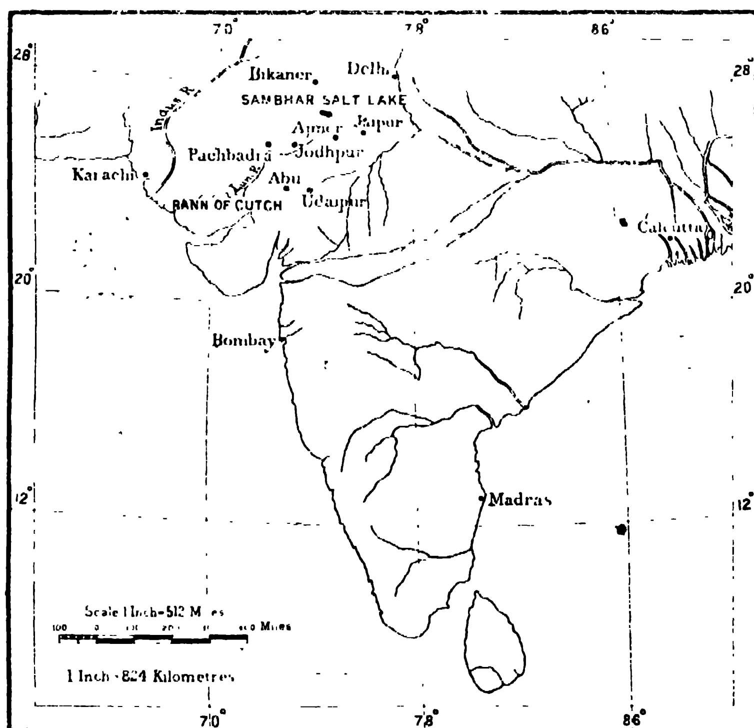
The Irrawaddy beds consist of the usual soft current-bedded sandstones with a few sandy limestone bands, and much fossil wood, mostly siliceous but sometimes calcareous. Near the base are ferruginous conglomerates with fragmental vertebrate remains. The "Red Bed" forming the base of the Irrawaddy series in so many places elsewhere, is absent here. The boundary between the Pegu and Irrawaddy series selected as the most probable and mapped by Mr. Sethu Rama Rau was the base of a sandy limestone associated with irregular patches of an ossiferous ferruginous conglomerate, overlying beds rich in selenite; the junction is probably an unconformable one. The thickness of Pegu beds exposed is probably about 200—250 feet.

Other deposits are :—the Red Alluvial Silt which is gravelly in places and occurs on high ground, and recent stream alluvium : neither of these call for further notice.

Prospects of obtaining oil.—The orientation of the Yenangyaung inlie is 27°—28° W. of N., that of the Ondwe inlier about 40° W. of N., while that of the line joining the two is very nearly the mean between them, so that the two Pegu exposures probably lie upon the same wave-front of the folding movement. This need not necessarily have any significance from an oil prospector's standpoint, but in the favourable structure of the rocks and the proximity of the area to Yenangyaung it is equal to some places which have been tested, and might be worth a deep experimental boring. No seepages occur. The Yin Chaung contains water all the year round and the locality can be easily reached from either Magwe or Myingun.

THE ORIGIN OF THE SALT DEPOSITS OF RAJPUTANA. BY SIR THOMAS H. HOLLAND, K.C.I.E., D.SC., F.R.S., AND W. A. K CHRISTIE, B.SC., Ph.D., *Geological Survey of India.* (With Plates 6 and 7.)

DURING the last few years, a special investigation has been made by the Geological Survey of India into the salt resources of the Sambhar Lake in Rajputana and naturally the origin of the salt has formed part of the enquiry.



Salt resources of Sambhar.

The Sambhar Lake is situated in the middle of a closed depression in the Aravalli schists, and is fed by four rivers—Menda, Rupnagar, Kharian and Khandel,—which, with some smaller streams, drain an area of about 2,200 square miles.

The lake at its highest level covers an area of about 90 square miles. For the greater part of the year there is no water on its surface, but, in seasons of normal rainfall, the depth of the water in the middle of the lake averages 4 feet in the monsoon.

The investigations referred to above have shown that the salt resources of Sambhar are confined to a body of saliferous silt, stretching over an area of 80 to 90 square miles and attaining depths in the centre of 60 to 70 feet. The analyses made of samples taken at regular intervals over the lake-bed show that in the upper 4 feet of silt over an area of 68 square miles, there is an accumulation of more than 18,000,000 tons of sodium-chloride. As other samples taken at depths of 8 to 12 feet show that approximately the same percentage of salt occurs in silt to the latter depth, there must be in the upper 12 feet of silt more than 55,000,000 tons of salt.

Other Rajputana Salt Lakes.

Sambhar is not the only salt lake in Rajputana. There are other smaller temporary lakes like Didwana, Falodi, Lonkara-Sur, and Kachor-Rewassa, while a brine-impregnated subsoil exists throughout the desert region, as well as in the country to the west, in Sind and around the Rann of Cutch. To the north of the Rajputana country also subsoil brine is raised and evaporated for salt in the districts south-west of Delhi, while to the north-west saline soils are common in Bhawalpur State and in the Punjab districts of Multan and Mazaffargarh. Shallow wells sunk in the sand in most parts of Rajputana are brackish, and the whole country is noticeably saliferous. There may be many Sambhars concealed by the mantle of desert sand.

Previous theories proposed to account for the Salt Lakes.

The first attempt to explain the origin of the Rajputana salt sources seems to have been made by Mr. A. O. Hume in his Report on the Administration of the Inland Customs Department for the year 1867-68. He refers to the salt in the Sambhar Lake as possibly a mere surface deposit, due to the drying up of an inland sea, or possibly according to some "the washings of countless ages out of the surrounding Permian formation."

Supposed marine origin.

To support the theory of a recent invasion of the sea in the Rajputana area, there is no positive evidence, and the idea that the salt

is due to evaporation of bodies of sea-water cut off from the retreating ocean is thus without foundation. During Lower Tertiary times the sea stretched over parts of Sind, Rajputana, and the Punjab, and the rock-salt deposits of Kohat and possibly those of the Salt Range were formed about then, although not necessarily by the isolation of bodies of sea-water. But no evidence as to the existence of Tertiary strata has been found anywhere near the Sambhar Lake, either superficially or by the borings recently made under the advice of the Geological Survey Department. The rocks around are various forms of schists belonging to the Aravalli system, resembling in general lithological characters the Dharwar system of South India. No rock-salt formations have ever been found in such rocks or in the Vindhyan formations in the adjoining parts of Rajputana, nor would the decomposition of these rocks give rise to any unusual quantities of sodium-chloride.

Supposed salt springs in the crystalline rocks.

In a report made in 1902, Dr. Noetling suggested that the salt of the Sambhar Lake is obtained from a subterranean saline spring arising along a fault-plane hidden by the mass of silt which now forms the bed of the lake. No proof exists as to the presence of a fault-plane, and no attempt was made to account for the occurrence of salt in a spring arising through the Aravalli schists: the idea of the existence of a saline spring rising through the schists is not supported by any more direct and positive evidence than is the local legend that the salt was once a mass of gold and silver converted by the thoughtful Devi into the less valuable product to prevent its being coveted by some of the powerful tribes in the country around.[1]

Mr. T. D. LaTouche accounts for this general prevalence of salt as follows:—

Suggested concentration of ordinary river water.

"It seems to me that instead of our being compelled to speculate on former extensions of the sea or great changes of level, no evidence of which is to be found in order to account for the presence of the salt a simple explanation presents itself in the peculiar conditions of the

[1] The idea of brine-springs in the bed of the lake was mentioned by R. M. Adam in 1870 (Report, Inland Customs Department, 1869-70, Appendix B, p. 12) as one of the theories for the origin of the salt. Mr. Adam favoured the theory that the salt came from the rocks around, which he thought to be Permian.

country as regards drainage and evaporation. The rain-water flowing from the hills is evaporated long before it reaches the sea, owing to the porous nature of the sand and the dryness of the atmosphere, and the salt it contains, which would under ordinary conditions be carried by rivers into the sea, and help to swell the amount of salt already there, is deposited among the sand grains, and in process of time has thoroughly impregnated the soil with salt. The process is in fact exactly similar to that which, it is universally admitted, accounts for the presence of the salt in the sea itself. Wherever depressions in the general level of the country occur, as at Pachpadra, Sambhar, and other places, the drainage from the surrounding higher ground concentrates the salt, until in course of time the accumulation has become so great as to be commercially valuable.

"It is perhaps not improbable that as particles of carbonate of lime are distributed over the desert by winds blowing from the south-west, and in time form beds of kankar, so also particles of salt may be blown up from the sea-shore and help to increase the amount of salt contained in the sand."[1]

Were the main part of the salt in the lake derived in the manner suggested by Mr. LaTouche from the decomposition of the surrounding rocks, one would expect that in these rocks and in the silt the ratios of chlorine to other soluble constituents (sodium, for instance), would be commensurate.

Taking F. W. Clarke's estimate of the relative quantities of the elements in the earth's crust,[2] we find the ratio of chlorine to sodium to be 2·88 : 100. Assuming that the composition of the rocks of the Sambhar basin does not differ greatly from Clarke's average, we should expect to find these elements in similar proportions in the Sambhar silt. Mr. D. Hooper's analyses of the unwashed lake mud, however, gave an average ratio of 161 : 100, about 56 times as great,—a figure which would indicate that we must look elsewhere for the source of the chlorine.

Mr. LaTouche's explanation does not account satisfactorily for the large quantities of salt in the small lakes at high levels, where the small rivers that flow in are rivers only for a short while after a heavy downpour of rain. We have no right to expect much salt in a river formed by a heavy downpour on a country of schists and quartzites, where there is little vegetation or animal life. For most of the year, there is no running water in the rivers and the processes of rock-decomposition that relieve sodium-salts must be almost at a standstill; even during the floods of the monsoon the

1 *Mem., Geol. Surv. Ind.*, XXXV, 1902, 42.
2 Data of Geochemistry: *Bul. U. S. Geol. Surv.*, No. 330, p. 32.

amount of chemical action on the rocks washed cannot be so great as that which occurs in a country of perennial springs and evenly distributed rainfall with abundance of life.

The geologist is accustomed to draw freely on time to explain such phenomena as the results of erosion, or the accumulation of salts in the ocean and salt lakes. He is, however, not justified in asking for more time than his rough data justify, and it appears to us that to account for all the sodium-chloride in the Sambhar Lake we should be driven by Mr. LaTouche's theory to assume that the present physiographical conditions of the Sambhar basin have persisted for a period that would be considered long even by a geologist. Taking again F. W. Clarke's estimate of the amount of chlorine in the Earth's crust[1] and C. Davison's figure regarding the rate at which the rivers of the globe lower their basins,[2] we should require, under existing physiographical conditions, 26,000 years to obtain the amount of chlorine in the upper 12 feet of silt under the Sambhar Lake. This minimum estimate of time necessary to relieve the quantity of salt in Sambhar is probably many times below the truth for the reasons that we assume in this calculation—

(1) that the Aravalli schists contain as much chlorine as the average rocks of the Earth's crust;

(2) that the average rate of denudation has been maintained in an area where we know denuding agencies have been extremely feeble during recent times;

(3) that during denudation complete rock-decomposition has occurred, and that all the rocks eroded have yielded their full amount of chlorine;

(4) that the salt-bearing silt is only 12 feet deep, whereas we know that there are further, and perhaps larger, quantities below;

(5) that chlorine makes up 0·07 per cent. of the Earth's crust: Clarke states that the estimate is probably too high.

These figures have no precise value whatever: they merely show that, when we assume the salt of Sambhar to be the result of the simple concentration of the small quantities carried by ordinary fresh river-water, it is necessary to be in a position to main-

[1] *Loc. cit.*
[2] C. Davison, *Geol. Mag.*, 1889, 409.

tain, either that this action has been in progress for very long ages without interruption, or that a larger area than the present basin has in the past been drained into the Sambhar Lake. The geologist has no right to ask for conditions that are not in any way indicated by the processes in operation, and it appears to us unreasonable to suppose that the amount of salt accumulated in Sambhar is the result of the concentration of quantities so small as we find in ordinary river-water.

River-water in the Sambhar basin.

As it seemed probable that the so-called fresh water of the rivers entering Sambhar carried more than the usual quantities of salt, one of us suggested the collection of samples from the flood-water of the rivers Menda, Kharian, Rupnagar, and Khandel. Sir Richard Dane, then Commissioner of Northern India Salt Revenue, who shared our misgivings about the theories regarding the origin of the salt in Sambhar, arranged to have samples collected at the beginning of the 1907 monsoon, and samples of the early flood-waters were taken similarly in 1908. These have been examined by one of us in the Geological Survey laboratory. The following table gives the sodium chloride per million parts of river-water, calculating all the chlorine present as sodium chloride:—

	1907.	1908.
In the Menda	1,395	25,300
" Kharian	665	575
" Rupnagar	77·0	74·2
" Khandel	10·85	63·8

The very wide variations in these results have yet to be explained; but all four samples of river-water contain so much more chlorine than is usual in fresh-water rivers that there is now less difficulty in accounting for the *immediate* origin of the large stocks of salt in the Sambhar silt.

Sir John Murray[1] calculates that in nineteen of the large rivers of the globe each cubic mile of river-water contains 16,657 tons of sodium chloride, 2,462 tons of lithium chloride, and 1,030 tons of ammonium chloride. The chlorine in these compounds amounts

[1] *Scott. Geograph. Mag.*, III, 1887, 76, 77.

to 12,840 tons, that is, chlorine sufficient for 21,180 tons of sodium chloride. As a cubic mile of river-water weighs about 4,205,650,000 tons, the chlorine estimated as sodium chloride in the large rivers of the globe cannot exceed 5·04 parts per million of river-water. This is less than half the amount found in the least saline of the Sambhar tributary rivers, and of course very much less than that found in the Menda, which is the most important, and discharges a larger body of water than any, of the rivers entering the Sambhar Lake. The figures quoted for ordinary river-water are admittedly approximate, the variations from river to river and from time to time in the same river being too great to permit of the preparation of a reliable average. We are safe, however, in assuming that the rivers entering Sambhar, though stated to be fresh, are comparatively saline.

But we have still to account for the existence of these large quantities of salt in the small basin of only 2,200 square miles drained into Sambhar. Rock-decomposition is reduced to a minimum in such a dry climate, and the rocks of the basin, being schists not rich in alkaline minerals, are of a kind that would be below rather than above the average in yielding alkaline chlorides. At the higher levels, where the principal salt lakes occur, one would expect ordinarily that the country would be deficient in salt rather than overstocked with it, for no drainage is received from outside areas, and nothing contributes to the relief of the chlorides contained in the subjacent rocks.

Possible subterranean percolation from the Punjab.

It is distantly possible that some salt is brought into Rajputana by the water percolating underground from the irrigated areas of the Punjab. Considerable quantities of water are obtainable from the sandstones at about 100 feet below the lignite seam of Palana in Bikaner, that is, about 300 feet below the surface. It is just possible that this water, and some of that in the deep wells throughout Rajputana, comes underground from the Punjab, and the gradual passage of this to the surface by capillary attraction would result in the superficial deposition of the various dissolved salts as the water dried up. We can suggest no means at present for proving that this is the origin of the deep-well water in Rajputana, or that in this way salt is imported to the desert area. It is likely, however, that only the areas of lower levels to the north and west of Jodhpur and north

of Barmer receive such water, and these are outside the main salt-bearing tracts. Sambhar, for instance, is at an elevation of 1,184 feet and is the bottom of a closed basin of schistose rocks. It is not possible, therefore, that any of the water in the Sambhar basin can have come from the irrigated lower levels of the Punjab. The same is true of the salt lake of Didwana at an elevation of about 1,150 feet; Kachor-Rewassa at about 1,590 feet; Degana at about 1,200 feet; and the small salt lakes near Kachawan: all these are within the Aravalli schist area and at comparatively high levels.

Pachbadra, however, is at an elevation of only 400—500 feet, and is outside the Aravalli schist belt; but between it and the Punjab there are higher levels of 900—1,000 feet in the region of Pokaran and Falodi, while the ground to the north-westwards falls away towards the dry valley of the ancient Saraswati (Ghaggar) river, and thence down to the valleys of the Sutlej and Indus. It is unlikely that any of the underground water in the Pachbadra area comes from the Punjab region, as whatever water passes in this way underground from the irrigated areas of the Punjab probably gravitates towards the low ground to the north-west, emerging in the valleys of the Ghaggar, Sutlej, and Indus. We are not justified, therefore, in assuming that any salt is brought to the highlands of Rajputana by subterranean water; and the quantities are far too great to be the result of rock-decomposition within the area.

Absence of ancient rock-salt deposits.

The possible occurrence of geologically old rock-salt beds below the silt and sand has been suggested more than once; but evidences as to their occurrence are quite negative. Although the subjacent rocks are largely concealed by the great mantle of sand, the numerous outcrops exposed on the west of the Aravalli range show nothing but schists and crystalline rocks over a wide zone, and the nearest unaltered sedimentary rocks are of the Vindhyan series, which have never revealed any traces of rock-salt. Still further west occur representatives of the nummulitic formations such as we know to be associated with the rock-salt deposits of Kohat; but in Rajputana no rock-salt has been found with this formation, although they have been cut through deeply in the Palana coalfield. In any case, if rock-salt were found below the nummulitic rocks of Bikaner they could not have contributed to the superficial salt on the crystalline highlands of Jodhpur and Jaipur.

Walther's theory.

Professor J. Walther, in his well-known work *Das Gesetz der Wüstenbildung*, suggested that the generally saline character of desert regions is due to the salt in marine formations being brought to the surface by capillary action to form a superficial efflorescence, which is afterwards washed by the sudden floods (that also characterise desert areas) into the lower parts of the desert basin, and there, after evaporation of the water, is left as a layer of salt. This last part of the process is seen in all regions of internal drainage where desiccation exceeds precipitation. But Walther's theory does not appear to have met with general acceptance, partly because it does not account satisfactorily for the large quantities required to make enormous rock-salt beds of the kind known, for instance at Stassfurt, in Galicia and in North-West India. Even for small quantities we cannot accept the theory as applicable to most of the salt-lakes on the Rajputana highlands: they rest on crystalline rocks, and any salt they yield must be relieved by rock-decomposition, and, under the circumstances, must be a small, perhaps negligible, quantity.

Wind-borne Foraminifera in the desert sand.

It occurred to one of us that the last point mentioned by Mr. LaTouche, as a contributory cause of a purely subordinate kind, is in reality the main source of salt in the Sambhar basin and in the Rajputana region generally,—namely, that most of the salt is brought in in the form of fine dust by the strong south-west winds that blow across the salt-incrusted region of the Rann of Cutch during the months of April, May, and June of each year. In another part of his memoir Mr. LaTouche refers to the discovery, among the fragments of carbonate of lime found in the sand, of foraminifera resembling those that occur in the Tertiary rocks of Cutch.[1] These have been found as far inland as 40 miles to the north-east of Bikaner, or 500 miles from Cutch, and Mr. LaTouche concludes that they must have been carried so far by the wind. He also calls attention to the angular nature of the small sand grains in the Bikaner desert as additional evidence that the wind-borne material has undergone only a limited amount of attrition. Mr. LaTouche has not, however, drawn attention to the difference between the

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[1] Wind-blown calcareous rocks largely composed of foraminifera have been found in Kathiawar, being similar to the well-known Porebandar stone and of recent geological age (J. W. Evans, *Quart. Journ. Geol. Soc.*, LVI, 563).

heavy grains that are rolled along by the wind and thus rounded, and the lighter materials that are carried bodily by the wind, and thus escape attrition. As granules of sand and carbonate of lime can be carried to such considerable distances inland, so also presumably large quantities of salt must be carried yearly by the south-west winds which pass over the dry salt plains of Cutch and thence into Rajputana. Salt is specifically lighter than the quartz sand grains or the granules of carbonate of lime, and its tendency to form in skeleton, so-called "hopper shaped," crystals, renders it more likely to be lifted by the wind.

Prevailing winds.

The force and direction of the strong winds are shown by the configuration of the sand-hills. The sand-hills marked on quarter sheets Nos. 11 N.W. and N.E. and 10 S.E. are long parallel ridges aligned in a S.W.—N.E. direction, while further N.E., where the force of the wind is reduced, the sand-hills shown in quarter sheets Nos. 19 N.E. and 18 S.E. have main ridges running N.W.—S.E. with subsidiary ridges on the windward side, pointing S.W. These interesting differences between the two classes of sand-hills have been explained and illustrated by Mr. R. D. Oldham in the 2nd edition of the Manual of Indian Geology (page 456). The longitudinal ridges are formed in the area of very strong winds, while the transverse ridges are formed further N.E. where the force of the wind is reduced.

It thus seemed possible that the salt carried by the south-west wind into Rajputana would account for most of that which is found impregnated in the soil throughout the desert region. By the floods formed during each monsoon this salt would be washed into certain local depressions and thus give rise to the numerous salt lakes.

The numerous accounts that have been published of the Rann of Cutch seem to leave little room for doubt as to the occurrence of a large area covered with sand and silt impregnated with dry salt. The descriptions by Sir Alexander Burnes in the *Transactions of the Royal Asiatic Society*, Vol. III, pages 550 to 558, by A. B. Wynne in his Memoir on the Geology of Cutch (*Mem., Geol. Surv. Ind.*, Vol. IX, p. 14), and most recently by Mr. R. Sivewright of the Public Works Department of India (*Geographical Journal*, Vol. XXIX, 1907, p. 518), leave no room for doubt as to the dry character of the country, the large quantities of superficial salts in the sand, and the heavy dust-storms that characterise the period of strong winds during the second quarter of the year.

The Climatological Atlas of India, issued by the Meteorological Department in 1907, shows by the maps forming Plates XXVII *et seq.*, that during April strong winds set in in the E.N.E. direction across the delta of the Indus and that strong south-west winds pass up the valley of the Luni river, as recorded at the meteorological station of Pachbadra. During the same time, westerly winds blow in the direction of Mount Abu and Deesa from the neighbourhood of the Rann of Cutch. These presumably also carry salt; but, as they carry it into an area from which afterwards it is washed out by the heavier rain that falls east of the Aravallis, it is carried away by the rivers that flow into the Gulf of Cambay. During May, the south-west winds continue from the Cutch area into Rajputana, and these are still more pronounced during June. As the force of the wind is reduced in the area west of Delhi and interrupted by currents from other directions, the effect of this north-eastwardly wind during the hot dry weather must be practically limited in its salt-bearing capacity to Rajputana and the south-west part of the Punjab. The winds maintain similar directions, with apparently equal force during July, August, and September, but their ability to pick up salt from the salt deserts of Cutch must be considerably reduced when the ground becomes wet after the break of the monsoon in June.

Transport of sea-spray by the wind.

That salt is carried by winds blowing from the sea has of course long been recognised, and an allowance was made by Prof. J. Joly[1] for the effect of this return of salt to the land in his well-known estimate of the age of the Ocean.

Fine drops of sea-spray become quickly evaporated when rain does not accompany the wind, and the residual particles of salt are probably even more easily transported than the spray.

The Rivers Pollution Commission, in their Sixth Report,[2] noted the liability of winds to carry sea-spray,—a point enlarged upon by R. Angus Smith,[3] who showed that the quantity of salt contained in rain water varies with the distance from the coast. Many subsequently published "chlorine maps" have confirmed the statement.

[1] *Sci. Trans., Roy. Dub. Soc.*, VII, 1899, p. 23, and subsequent discussion in *Geol. Mag.*, 1901, 344-350 and 504-506.
[2] 1868, p. 19.
[3] Air and Rain, p. 263.

Previously suggested æolian origin of salt deposits.

The æolian origin of salt deposits was suggested by F. Posepny[1] in 1877 in a paper on the Salt Lakes of the Western States of America. He based his theory on a comparison of the amount of salt carried annually from Bohemia by the Elbe, with the quantities used for industrial and domestic purposes, and emitted by mineral springs, in the drainage area of that river. The excess contained in the river-water he attributed to salt carried in the air from the sea, quoting an analysis of rain-water from Nancy to prove the presence in the air of chlorides in sufficient quantity to justify his supposition. On applying the figures obtained to the question of the Great Salt Lake, he calculated that an amount of salt equal to that in the lake would have been deposited in a closed basin of the area of Bohemia in six thousand years.

The suggestion was immediately disputed by E. Tietze,[2] who pointed out certain flaws in Posepny's argument, and concluded that the genesis of most salt deposits, and more particularly of those in Persia, could be explained on more old-fashioned assumptions.

The theory advanced by Posepny received little recognition for over twenty years. It was revived by W. Ackroyd[3] in a number of papers on the atmospheric circulation of salt; Ackroyd, who studied the chlorine content of the rocks of the neighbourhood, concluded that the salt of the Dead Sea must have been carried by the wind from the Mediterranean.[4]

E. Dubois,[5] in a recent paper, has discussed quantitatively the question of atmospheric transportation, from data concerning the amount and composition of the rainfall on a strip of land 31,000 hectares in extent on the west coast of Holland. He points out that computations made from ordinary rainfall statistics and analyses are inadequate for the purpose, as the amount of salt reaching the soil in ways other than precipitation by rain is neglected. From lysimetric measurements by H. de Bruyn of the water percolating through the sand dunes between the Hague and

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1 *Sitz. b. d. k. Akad. Wien*, 1878, 179.
2 *Jahrb. der k. k. geol. Reichsanst.*, 1877, 341.
3 *Chem. News*, 7th June 1901, p. 265, and 2nd August 1901, p. 56; *Geol. Mag.*, 1901, p. 445; *cf* also J. Joly, *Chem. News*, 28th June 1901, p. 301.
4 *Chem. News*, 8th January 1904, p. 13.
5 *Arch. du Musée Teyler*, Ser. 2, Vol. X, p. 461.

Scheveningen, he calculates the total rainfall on the 31,000 hectares in question. Assuming that the water derives no impurity from the soil, and that analyses of the water used in Amsterdam and the Hague, whose supplies are derived from the belt in question, represent the average composition of the water over the whole belt, he calculates that 20,000 kg. of salt are annually deposited from the atmosphere on each square kilometre. He proceeds to apply these figures to the question of the origin of the salt in the Great Salt Lake, and calculates from G. K. Gilbert's[1] data that the time required for the accumulation of the salt in the Great Salt Lake in this manner would be 143,000 years—a period which he regards as many times in excess of its probable age. It should be noted, however, that Dubois takes the amount of salt in the basin as twenty times that estimated by Gilbert to be contained in the Great Salt Lake, and that he assumes that the rate of atmospheric transport is only one-fiftieth of that found on the Dutch dunes.

The transport of salt by the wind is mentioned by J. Walther[2] as a co-operating factor in the formation of desert salt deposits, and by R. Beck[3] as a possible source of the chlorine in the cerargyrite of arid regions. The latter question has been fully discussed by C. R. Keyes,[4] who concludes that this hypothesis "is probably more important in the desert regions generally than all of the others combined."

Criticisms by local officers of the Salt Department.

The suggestion of the wind-borne origin of the Rajputana salt deposits was submitted for criticism to officers of the Department of Northern India Salt Revenue with long experience of the districts in question. Messrs. G. Buckley and G. T. Scully had seen no evidence of salt being carried by the wind. Mr. E. D. Nunn, on the contrary, stated that when out across country away from the salt works at Sambhar, it is possible to taste the salt on one's lips in the hot windy weather, while crystals of salt up to a quarter of an inch in diameter have been carried 1,000 yards by the wind at Sambhar itself. The dew, too, that collects on the *Faras* trees in the desert is, according to Mr. Nunn, distinctly saline.

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1 *U. S. Geol. Surv., Mon.* I.
2 Das Gesetz der Wüstenbildung, 1900, 145.
3 Nature of Ore-deposits: Translation by W. H. Weed, Vol. II, 375.
4 *Trans. Amer. Inst. Min. Eng.*, January 1908, p. 28; *Econ. Geol.*, II, 778.

Comparison of Sambhar Lake-brine with Oceanic waters.

The composition of the brine contained in the Sàmbhar Lake presents no features which are not easily explained on this theory. The following is a typical analysis of the residue obtained on evaporating the lake-brine; the mean of 77 analyses of ocean water[1] is given for comparison :—

	Sambhar Lake. (W. A. K. Christie.)	Ocean. (W. Dittmar.)
Na	38·86	30·593
K	0·09	1·106
Ca	trace	1·197
Mg	0·01	3·725
Cl	52·96	55·292
SO_4	5·85	7·692
CO_3	2·19	·207
Br	0·04[2]	·188
	100·00	100·000

The Sambhar brine contains also traces of NH_4, Fe, S, SO_3, BO_3, PO_4, I and SiO_2.

The chief points of difference in the analyses lie in the excess of carbonates and the deficit of potassium, calcium, magnesium and bromine in Sambhar brine as compared with sea-water.

The comparatively large proportion of sodium carbonate is probably due to the reduction of sodium sulphate to sulphide[3] by the decomposition of organic matter, which, chiefly in the form of algæ, abounds in the lake after the rains. The sodium sulphide is then acted on by the carbonic acid of the atmosphere, reinforced by that liberated by the decomposition of the algæ, and sodium carbonate is formed, the sulphuretted hydrogen given off[4] being doubtless to a great extent responsible for the intolerable stench prevalent at Sambhar when the lake is drying up. The intense blackness of the lake mud is also due to sulphuretted hydrogen, black ferrous sulphide being formed from the iron compounds in solution and suspension. The sodium carbonate formed

1 Challenger Rep., Phys. and Chem., I., p. 203, 1884.

2 Determined by Dittmar's method. *Ibid*, p. 91.

3 *Cf.* E. Sickenberger, *Chem. Zeit.*, 1892, pp. 1645, 1691. Quoted by Clarke, Data of Geochemistry, p. 194.

4 $Na_2S + CO_2 + H_2O = Na_2CO_3 + H_2S$.

by the reaction would precipitate from the brine as carbonates any calcium and magnesium salts introduced as chlorides or sulphates.

According to J. Usiglio,[1] when sea-water is evaporated, calcium carbonate and sulphate are the first salts to be precipitated. Sodium chloride, with small quantities of calcium and still smaller quantities of magnesium as sulphates and chlorides, crystallises next. When 91·3 per cent. of the total sodium chloride has separated, the bittern still contains 88 per cent. of the original magnesium as chloride and sulphate with the greater part of the potassium and the bromine. Apart from the possibility of these salts being drained away, we must remember that magnesium chloride is a very deliquescent substance, so that the bitterns would not be likely to become dry enough to be transported by the wind, whereas the purer salt crystals would. We may thus explain the deficit in potassium and bromine found in the lake-brine.[2]

The argument finds some corroboration from a consideration of the relative proportions of calcium and magnesium salts in the lake mud. We should expect to find the ratio of calcium to magnesium much greater than in sea-water. The proportion of calcium to magnesium in the lake mud, as determined in 1904 by Mr. D. Hooper, Curator, Industrial Section, Indian Museum, is 286 : 100. Their relative proportions in sea-water are 32 to 100.

Method of investigation.

The best test of such a theory would be a series of determinations of the amount of salt held in suspension by the winds prevailing between the salt deposits and the supposed source of origin. Analyses of rain-waters can tell us much, but the fact that they only allow us to compute the amount of salt actually in suspension at the commencement of the fall renders estimates based on them valueless except for qualitative and comparative purposes.

Rain-storms in desert regions are also often preceded by local wind-storms of irregular direction, and as the arrival of the first drops cannot be predicted with absolute certainty, it is impossible to be sure that the rain-gauges are not tainted with the locally raised saline dust.

[1] *Ann. Chim. Phys.*, 3rd ser., Vol. 27, p. 185.

[2] The relative proportions of iodine in the ocean and in the Sambhar brine are almost the same as those of bromine. The iodine found in the Sambhar brine residue amounted to 0·00130 per cent. A. Gautier's figure for the total iodine in ocean water (*C. R.*, Vol. 128, p. 1069) is about 0·0070 per cent.

With the co-operation of the Meteorological Department, however, samples of rain-water were collected from several places in Rajputana at the beginning of the rains in 1909, the arrangement made for the collection of such samples in 1908 having been frustrated by an unusually early and unexpected burst of the rains. Rain was collected at the following places (see map on page 1), Jaipur, Sambhar, Bikaner, Ajmer, Jodhpur, Pachbadra, Udaipur, and Abu. Detailed instructions as to the method of collection were issued to the meteorological observers, who were specially cautioned about the necessity of having the rain-catching apparatus washed immediately previous to the fall with distilled water sent for the purpose.

The results given below are in parts of chlorine per million :—

Place.	Date.	Parts of chlorine per million.	Distance from nearest part of Rann of Cutch.
	1909		
Jaipur	June 13th	0·51	310
Sambhar[1]	June 14th	0·98	280
Bikaner	June 29th	2·3	250
Ajmer	July 1st	0·31	230
Jodhpur	June 28th	3·7	150
Pachbadra	June 16th	5·1	100
Udaipur	June 13th	6·0	130
Abu	June 13th	0·16	80

It would not be safe to infer much from such isolated data, but comparison with the chlorine maps of the eastern maritime provinces of the United States,[2] in which the isochlor lines run nearly parallel with the coast line, shows that the figures are greatly in excess of the normal amount of chlorine found at similar distances from the coast. The curve corresponding with 1·0 part of chlorine per million lies at about 50 miles from the Atlantic coast, the 0·5 line being about 100 miles distant from the sea.

The exceptional lowness of the Abu figure is due partly to the fact that the station is about 4,000 feet above sea-level, and partly to the prevalence of an easterly wind when the rain fell.

It is evident that the most reliable evidence on the question would be obtained by sampling the hot-weather winds which blow steadily in a roughly N.N.E. direction from the salt-incrusted Rann

[1] The first part of the fall was not collected.
[2] U. S. Geol. Surv., Water Supply and Irrigation Paper No. 144.

of Cutch into the Rajputana desert. An attempt was therefore made to determine directly the chlorine content of the air in Rajputana during the hot weather of 1908. Our first intention was to sample the air simultaneously at various places along the Cutch-Sambhar route traversed by the hot winds. Various devices were tried in the laboratory with the object of finding a method of catching salt in the wind sufficiently accurate for the purpose of the enquiry, and simple enough to be manipulated by the resident observers whose services we hoped to obtain,—amateur observers, who would not be able to devote much time to the work.

Preliminary Laboratory tests.

A miniature wind, whose velocity was determined by a small aluminium anemometer, was made by a 16″ electric fan. A stock of finely powdered dry salt was kept in a vertical wedge-shaped bottle, whose opening at the upper and wider end was closed by a stopper with two holes. Through the one a glass tube connected with a foot bellows reached to the bottom of the flask, through the other a delivery tube, cut off just below the cork, conveyed the dust in front of the centre of the revolving fan, where it terminated in a "spray nozzle" such as is used for washing in photography. The object of the wedge-shaped bottle was to insure that there would always be a supply of dust covering the mouth of the tube connected with the blast; that of the "spray nozzle," to distribute the dust evenly in the plane in which the fan revolved. With this apparatus the results obtained by various methods were compared with those obtained by aspirating a known volume of the air through water. The speed of the wind used in the experiments was about 9 miles per hour.

Two layers of fine muslin mosquito-netting (5 holes to the c.m.), placed on a frame one five c.m. behind the other in planes perpendicular to the direction of the wind, and kept moist partly by capillary attraction from water in a covered trough below, and partly by a distributing reservoir above, showed the air to contain 7·1 per cent. of the amount determined by aspiration, *i.e.*, 7·1 per cent. of the total salt contained in such a quantity of air as would have passed the area covered by the netting, had that been removed.

A series of five strips of 9 c.m. broad lamp-wick were set up vertically 1 c.m. apart, parallel to one another and to the direction of the wind. The lower ends of the strips dipped into a covered trough of water, the wicks being thus kept moist. The

idea, due to Dr. Morris Travers, was that the wind, eddying in the passages between the strips, would deposit its salt on them. The amount found was 11·0 per cent. of that determined by the aspirator method.

A lamp-wick, set up vertically in a plane perpendicular to the wind direction, with its lower end dipping into water, collected 8·0 per cent. of the total. A similar wick, dipping into a bottle at its lower end, and communicating with a bottle above filled with water, was made to act as a slow siphon; the water flowed from the upper to the lower bottle down the wick, keeping it continually moist. This recorded an average of 12·6 per cent. of the total salt. It was found to be the most convenient method for determining the relative quantities of salt in the air at different elevations, and will be described more fully later.

Various other devices,—a glass plate smeared with vaselin,—a glass funnel placed with its mouth to the wind, and its bent stem dipping into a bottle filled almost to the stem with water,—a miniature imitation of rain-washing by means of a dropping-bottle, the size of the drops, the number of them falling in a given time, and the distance of their fall being known, etc., were tried with disappointing results. It was not, of course, to be expected that such contrivances would indicate the absolute quantity of salt in the wind directly, but the percentage found was surprisingly low. If this were constant for one form of apparatus, a factor could be introduced into the calculation to give the absolute quantities present, but the factor varies with the speed, and—more embarrassing—with the gustiness of the wind.

No method being found at once accurate and simple enough for the project of amateur observations along the Cutch-Sambhar route, it was decided to use the aspirator method in a series of determinations at one place only,—about half way between Sambhar and the Rann.

Various types of aspirator have been devised for such purposes. For taking large samples of air, the ordinary method with two interchangeable bottles, water flowing from the upper to the lower, is too inconvenient to manipulate, while the technical method of using a bellows, whose capacity is more or less definitely known, was deemed too inaccurate for the purpose. R. Angus Smith[1] recommended a large wide-mouthed bottle with a rubber bellows

[1] Air and Rain, p. 450.

at the top, and used also a pump driven by a windmill, the number of whose revolutions was automatically recorded. Similar suggestions were kindly made to us by Mr. W. H. Pickering and the late Mr. J. Lomas. O. Hahn[1] has described a very portable form of aspirator, the self-recording pump of which is worked by a motor driven by accumulators. The chief defect of such instruments lies in the fact that no matter what resistance there may be to the entrance of the air (and the "head" of water in the absorption vessels is not constant), the pump will always complete its stroke, the pressure in the cylinder, and consequently the quantity of air aspirated, being thus rendered indefinite. The windmill methods, too, suffer from the defect that, without special regulating contrivances, the rate of aspiration in a strong wind would be too great for efficient washing, if the apparatus is to work at a reasonable rate in a gentle breeze.

Apparatus selected for operations in the desert.

The aspirator it was decided to use was of the same type as the large gasometers used in gas works. The outer vessel of galvanised iron (see Plate 6) was 90 c.m. high and 40 c.m. in diameter, with a small horizontal slit 5 c.m. from the top. The inner cylinder was provided with a brass scale on its outer surface running from top to bottom, and so graduated that when water overflowed through the slit in the outer cylinder, and the air in the inner cylinder was under atmospheric pressure, the reading on the scale opposite the slit gave the volume of air in the gasholder. Two sets of three guide rods each, one inside reaching from the bottom 90 c.m. high, and the other fixed to the top of the outer cylinder and reaching upwards for about 90 c.m., kept the inner cylinder in position. The latter was raised by means of weights attached to a rope passing over pulleys supported by the outer guide rods. It was fitted at the top with a thermometer and two stopcocks, one communicating with a manometer and the other with the washing apparatus. The gasometer was calibrated by drawing air from it into a graduated glass aspirator. The air was freed from salt by making it bubble through water in an Erlenmeyer flask, and then through water contained in a Contat-Göckel "Aufsatz"[2] (see Pl. 6). It then passed through a vertical glass tube with two bulbs before passing by a 5 metre rubber tube to the aspirator. The glass tubes in the washing

[1] *Gesundheitsingenieur*, 1908, p. 165.
[2] *Zs. angew. Chem.*, 1899, 620.

apparatus, being always covered with moisture inside, helped considerably in the absorption.

The question arose as to how the air-inlet tube should be placed with reference to the direction of the wind. If placed facing the wind, a certain amount of salt would be blown in, besides the quantity sucked in by the aspirator, whereas, if placed perpendicularly to the wind direction, the tube itself being horizontal, or if facing leeward, the amount found would be less than the true value. A laboratory experiment, with a tube 19·5 m.m. wide placed vertically, and a wind blowing at 10 miles an hour carrying salt particles which had passed through a sieve of 36 meshes to the c.m., showed that over 50 per cent. of the amount of salt found had adventitiously dropped in.

To avoid these errors, the mouth of the inlet tube was placed so that it faced the prevailing direction of the wind, and the amount to be deducted on account of salt blown into the washing apparatus,—as distinct from that sucked in—determined by means of a second apparatus similar to that attached to the aspirator. The two were set up close together, their air-inlet tubes being parallel to one another.

This use of a "blank" experiment, carried out under the same conditions as the other, had the further advantage of eliminating incidental errors,—arising from impurities in the water used, from solution of salts from the storage bottles, etc.,—a more important consideration here than in most cases, as the quantities dealt with were so minute that a comparatively small error would have vitiated the results completely.

Field operations.

The apparatus was set up in April 1908 near Pachbadra (25° 55′ N., 72° 11′ E.), about 220 miles W.S.W. of the Sambhar Lake and some 150 miles N.E. of the Rann of Cutch. In the neighbourhood of Pachbadra, as in many other places in the Rajputana desert, salt is recovered from the soil in considerable quantities. The apparatus was therefore set up about 3 miles W.S.W. of the circuit bungalow, *i.e.*, windward of the pits where salt is manufactured. The wind is quite constant during the hot-weather months, so that no contamination from manufactured salt was to be feared. A site was selected at the top of the windward end of a long, gently sloping dune, running S.S.W.—N.N.E., whose surface sand contained ·005 per cent. of sodium chloride. The aspirator was enclosed in a tent placed 5 metres S.E. of the absorption apparatus.

The zero mark on the scale having been brought to the level of the water at the slit, weights aggregating 45 kg. were put on. Water was then poured into the outer cylinder to replace that sucked up into the inner one, and prevent air from entering the latter from below. Suction was then started by opening the stopcock connected with the washing apparatus. The aspirator was usually filled in about 20 minutes, when the stopcock was closed. The pressure of the air inside was brought to that of the atmosphere by removing some of the weights, during which operation water overflowed from the slit into a reservoir. As soon as the manometer showed the pressure inside and outside to be the same, and water ceased to overflow at the slit, the reading of the scale at the slit was taken and the temperature of the air in the gasholder noted.

The apparatus was then brought to zero by taking off all the weights and removing the thermometer stopper. When the water level coincided with zero on the scale, the stopper was replaced and aspiration begun again, water being poured back from the reservoir as soon as the weights had been put on. The anemometer and wind-vane were read at the beginning and end of each aspiration. The operations were repeated until two or three cubic metres of air, as a rule, had been washed, the absorption apparatus being replenished with water from time to time as evaporation proceeded. At the end of an experiment, the solution was transferred in the circuit bungalow to a 200 c.c. flask, and the separate pieces of the apparatus were carefully washed. The blank apparatus received the same treatment as the other.

Method of determining the chloride collected.

The amount of salt contained in the solution was afterwards determined in the Geological Survey laboratory by the ingenious nephelometric method due to T. W. Richards.[1] Without the nephelometer, the investigation would have been much more difficult, if not impossible. The opalescence produced in a salt solution of unknown concentration on the addition of silver nitrate is compared with that produced in a solution of known strength. The concentrations are varied until they are nearly the same, when comparison in the nephelometer gives the ratio of the concentration of the known to that of the unknown solution.

[1] T. W. Richards, *Proc. Am. Acad.*, 30, 385, 1894.
T. W. Richards & R. C. Wells, *Am. Chem. Jour.*, 31, 235, 1904.
R. C. Wells, *Am. Chem. Jour.*, 35, 99, 1906.
T. W. Richards, *Am. Chem. Jour.*, 35, 510, 1906.

The concentration of the solution obtained from a "blank" experiment was first determined by comparison with a known salt solution. The amount of a standard solution of salt, which had to be added to the "blank" solution to make it approximately equal in strength to the solution through which air had been aspirated, was then estimated and the similar solutions compared in the nephelometer; *e.g.*, a blank solution was found to have a concentration of 0·928 $\frac{N}{100,000}$ sodium chloride; 25 c.c. of this with 0·250 c.c. of $\frac{N}{1,000}$ sodium chloride, 1 c.c. of $\frac{N}{100}$ nitric acid and 1 c.c. of $\frac{N}{100}$ silver nitrate compared with 25 c.c. of the solution through which air had been aspirated + 0·25 c.c. of water + 1 c.c. of $\frac{N}{100}$ nitric acid + 1 c.c. of $\frac{N}{100}$ silver nitrate gave as an average of six readings the ratio of concentrations 0·940 : 1. The total amount of sodium chloride in the first solution was 25 × 0·928 × 0·000000585 + 0·25 × 0·0000585 g., *i.e.*, ·00002819 g. The total in the second was 1/0·940 × 0·00002819 g. The net amount of salt in 25 c.c. due to aspiration was therefore 1 0·940 × 0·00002819 − 25 × 0·928 × 0·000000585, *i.e.*, ·00001642 g., and in 200 c.c. 0·0001314 g., which represents the total quantity of salt aspirated during the experiment.

The water used in these determinations and also in the field was redistilled from a still and condenser of Jena glass directly into a large glass receiver connected at the top with a cotton wool filter and soda lime tower, so that the water came in contact with no air which had not been freed from chlorides. The receiver was fitted with a siphon delivery tube at whose end was a Jannasch filtering-tube packed between two perforated platinum discs with glass wool, and fitted with a dust-proof stopper. Water distilled in an apparatus whose delivery tube was open to the atmosphere was found to absorb chlorides from the gas supply in sufficient quantity to vitiate the results.[1] Water obtained in the above way after the still had been working for a fortnight showed with silver nitrate no trace of opalescence when tested in the nephelometer.

Results.

The results given in the following table show the quantity of salt in g. per cubic metre of air. The volume of air has in each case

[1] The quantity of hydrochloric acid formed by combustion of the purest alcohol obtainable was also not negligible.

been reduced to the volume it would occupy at 0°C. and 760 m.m. if free from water vapour :—

No.	Dates.	Hours.	Speed of wind, miles per hour.	Volume aspirated, M^3 at 0°C. and 750 m.m., dry.	Total salt found, grams.	Grams of salt per M^3 of air at 0°C. and 760 m.m., dry.	—
1	28th-30th April 1908.	20·23	22·0	1·622	·0001314	·0000810	Peligot absorption tube, 75 c.m. high.
2	3rd and 4th May 1908.	14·29	8·4	1·366	·0001811	·0001326	Erlenmeyer, 16 c.m. high.
3	5th and 6th May 1908.	14·24	7·2	1·469	·0000993	·0000676	Erlenmeyer, level with ground.
4	8th and 9th May 1908.	13·28	13·7	1·445	·0000557	·0000386	Erlenmeyer, 16 c. m. high.
5	10th and 11th May 1908.					Negative quantity.	
6	12th, 14th and 15th May 1908.	18·72	17·1	1·997	·0001274	·0000638	Erlenmeyer, 75 c.m. high.
7	16th-21st May 1908.						Determinations spoilt in the field.
8	23rd-26th May 1908.	21·0	19·6	2·081	·0000388	·0000186	Erlenmeyer, 75 c.m. high.
9	27th-29th May 1908.	21·23	29·6	2·430	·0000057	·0000023	,, ,,
10	30th and 31st May and 1st June 1908.	20·77	24·8	2·720	·0001001	·0000368	,, ,,
11	2nd-5th June 1908.	27·07	30·0	3·447	·000321	·0000931	,, ,,
12	6th-8th June 1908	19·67	36·1	2·559	·000448	·000175	,, ,,
13	9th-12th June 1908.	26·95	16·5	3·168	·000620	·000196	,, ,,
14	13th-16th June 1908.	25·52	15·1	3·006	·000368	·000122	,, ,,
15	17th, 21st, 25th and 26th June 1908.	22·07	21·6	2·620	·0000302	·0000115	Erlenmeyer, 75 c.m. high. 1·54" rain, 18th June 1908.
16	27th, 28th and 30th June 1908.	20·13	22·3	2·301	·0000682	·0000296	Erlenmeyer, 75 c.m. high.
17	1st, 3rd, 4th and 6th July 1908.	23·20	10·1	2·257	·000464?	·000206?	Erlenmeyer, 75 c.m. high. 0·2" rain, 3rd-4th June 1908.
18	13th-15th July 1908.	16·25	21·7	1·962	·0000117	·0000060	Erlenmeyer, 75 c.m. high. 3·5" rain, 7th-12th July 1908.

Naturally the clearer the atmosphere, the smaller was the amount of salt found. The dustiness of the air depended more

on the prevalence of miniature cyclones and on the gustiness of the wind than on its high velocity. Cyclones, whose dust-laden core is usually only a few yards in diameter, frequently sweep over the plains, and larger ones giving rise to blinding dust-storms are not uncommon. Four comparatively small ones were recorded in May, 1908, but all took place at night, and samples of the air at the time were not obtained. A small one passed over the observation station from the south-west on the afternoon of June 7th; the amount of salt collected during four days, of which June 7th was one, was ·000175 g. per cubic metre. According to the local residents, the air in the hot weather of 1908 was very much clearer than usual and the number of dust-storms exceptionally small. So pronounced a feature are they of the normal hot weather conditions, that the Pachbadra salt manufacturers, in anticipation of the bad effects of the dust, stop work at the end of April. In 1908, an unusual shortage in the output due to heavy rains in the previous year caused them to attempt to continue manufacture till the rains; and, owing to the exceptional nature of the season, the experiment was very successful. Mr. F. Ashton, formerly Deputy Commissioner of Northern India Salt Revenue, describes the conditions of the hot season as follows:—

"During the months of May and June, the hard level tracts of country along the Luni river become intensely heated, and the south-west wind, which passes over these, reaches Pachbadra as a fiery gale laden with dense clouds of heated sand. Under these conditions, the thermometer has been known to rise to 122° in the shade, and this temperature, with a gale of wind blowing and the atmosphere so thick with flying sand that it is impossible to discern objects at a greater distance than 100 yards, is intensely felt."[1]

We may take it then that the amount of salt found in the atmosphere in 1908 was less than normal. This is confirmed by the records of the Pachbadra meteorological station.[2] In 1908, the speed of the wind was in defect to the extent of 17·7 per cent. in April, of 15·3 per cen . in May, of 9·2 per cent in June, and of 43·1 per cent. in July when compared with the averages of the previous ten years.

Relation of wind-speed to dust-carrying capacity.

The amount of chlorine found is dependent to a considerable extent on the speed of the wind, though by no means proportional to it. This is scarcely to be expected, for the dust-raising capacity of a

[1] *Jour. Ind. Art. and Ind.*, 1901, p. 29.
[2] Monthly Weather Review, Calcutta.

wind depends much more indirectly on its average speed than on the prevalence of gusts of high velocity. A comparatively steady wind of low velocity and constant direction serves to a certain extent to sieve the salt impregnated grains and salt particles, so that the larger ones are at the surface, and also to arrange the particles so that they take up positions of maximum stability for that wind direction, from which they cannot be dislodged except by a wind of considerably greater speed or of different direction. As soon as the speed of the wind increases beyond a limiting value for a certain size of grain,[1] transportation can begin, and any small increase beyond this value causes a large increase in the transporting power. The deficiency, then, in the speed of the wind in 1908 may mean a considerable deficit in the amount of salt transported.

The effect of a high wind in raising salt dust may not reach a maximum until after the wind has commenced to subside; the observations from May 30th to June 11th illustrate this.

Salt-carrying capacity at different altitudes.

An attempt was also made to compare the amount of salt in the air at different heights. For this purpose, two pieces of apparatus like that shown in Plate 7 were fitted up at different elevations. A piece of lamp wick 2·65 c.m. broad, whose end reached to the bottom of a 50 c.c. bottle, was somewhat loosely clamped in position by means of two hemicylindrical paraffined corks about 2·7 c.m. wide, fitting the mouth of the bottle. The wick from the bottle was passed over a rubber roller *R*, and thence vertically down to the bottom of a second bottle similar to the first one, in which it was similarly fixed. Distilled water placed in the upper bottle siphoned over into the lower one in about 1½ hours, keeping the wick moist even in a high wind. All the wick, with the exception of 9·8 c.m. from *X* to *Y*, was enclosed either in the bottles or in the wooden box *B*, through a narrow slit *S* in the bottom of which it protruded. The apparatus was mounted on the bearings *MM* to act like a wind vane, so that an area of $9{\cdot}8 \times 2{\cdot}65$ c.m.^{2} was exposed perpendicularly to the direction of the wind. The height of the apparatus could be increased by means of extra pieces of gas piping *P*. As soon as the distilled water from the upper bottle had

1 For grains 0·25 m.m. in diameter for instance, the limiting velocity is 6·7 m. per sec. N.A. Sokolow, Die Dünen, Berlin, 1894, p. 12.

2 Monthly Weather Review, Calcutta.

siphoned over into the lower one, they were interchanged without removing the wick from either bottle, and the experiment continued. The bottles were replenished with distilled water from time to time through a small hole in the "leeward" cork.

At the conclusion of an experiment the wick was transferred by means of glass rods to one of the bottles and the salt extracted from it by repeated washing with distilled water; the solution was made up to either 200 or 250 c.c. and the chlorine determined nephelometrically, the two samples collected at the same time being determined together as described on page 174.

Laboratory experiments showed that, with a wind of 10 miles per hour, the apparatus absorbed on an average 12·6 per cent. of the total as determined by aspiration. The greater the force of the wind, the less efficient was the apparatus in extracting the salt from it, presumably from causes similar to those which prevent the formation, in a wind-swept sandy plain, of a bank of sand immediately windward of a solid obstacle—the development of eddies and counter-currents.[1] Comparative experiments in the laboratory with a similar apparatus and an aspirator showed, for instance, that a decrease of 48 per cent. in the speed of the wind (from 15 to 7· iles per hour) raised the "absorptive efficiency" by 12 per cent. of its value at the higher speed. The co-efficients of absorption used in calculating the values given below therefore varied slightly, the efficiency of the higher apparatus being less than that of the lower one because the speed of the wind increases with elevation.

The conditions of such experiments, however, are by no means strictly comparable with those of nature. S. P. Langley[2] has shown that in a wind of about 23 miles an hour, which would ordinarily be considered constant, enormous fluctuations occur many times per minute, the average interval from a maximum to a minimum being a little over 10 seconds, and the average change of velocity in this time being about 10 miles an hour. Owing to such considerations and to the difficulties of manipulation of the apparatus, the results given below can only be regarded as rough approximations. The figures have little absolute significance, but a relative one in so far as the assumption is justified

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1 *Cf.* P. Gerhardt, Dünenbau, Berlin, 1900, p. 328.
2 The Internal Work of the Wind, *Am. J. Sci.*, 3, XLVII, 50.

hat similar conditions obtain at elevations not differing widel om one another.

DATES.	Height of apparatus, c.m.	Speed of wind, miles per hour	Total salt collected, grams.	Total salt found at 75 c.m. = 100. Total amounts found at different heights are expressed in percentages of this.	Grams of salt per M^3 of air at 0°C. and 760 m.m., dry.	Amount of salt found per M^3 at 75 c.m. = t100. Amount found per M^3 at different heights are expressed in percentages of this.
12th-15th and 17th-19th July 1908.	75	11·16	0·001724	100	·00000886	100
12th-15th and 17th-19th July 1908.	150	13·07	0·001574	91	·00000703	79
25th and 26th July 1908.	75	1·73	0·000597	100	·0000263	100
25th and 26th July 1908.	225	6·92	0·000733	123	·0000216	89
27th and 28th July 1908.	75	7·41	0·000663	100	·0000160	100
27th and 28th July 1908.	300	11·70	0·000780	118	·0000117	80

Though the amount of salt per cubic metre of air is greater at lower levels, the quantity transported in a given time—and it is with that we are concerned, — shows no diminution with increase of elevation, on account of the greater velocity of the wind. This increase of speed is not confined to the layers of the atmosphere immediately above the surface, but persists to great heights.[1] Once the finer particles of dust have reached these upper layers, either by an upward gust of wind or by a small cyclonic disturbance, they seem to be held in suspension for considerable periods and distances. S. P. Langley[2] has shown that there is nothing dynamically inexplicable in bodies being able to rise against gravity or to remain suspended in the air provided the speed of the wind is variable; Vaughan Cornish[3] has suggested an electrical theory to account for the phenomenon; but whatever be the true explanation it is certain that large quantities of salt must be transported in this way.

son. J. *Scot. Meterolog. Soc.*, 5., Tab. IX and XI-LXIII. pp.
G. T. Walker. Rep. Bd. of Sci. Adv. of Ind., 1907-08, Calcutta, p. 159.
[2] *Loc. cit.*, p. 53.
[3] *Geog. Jour.* XXXI, p. 402.

Chlorine has been found in the atmosphere at considerable heights; A. Muntz[1] found 0·34 m.g. of sodium chloride per litre in rain water collected on the Pic du Midi in the Pyrenees, 2,877 m. high. The amount is certainly very much less than what Muntz found in rain water falling in the plains at Bergerac, some 200 k.m. north (2·50 g. per l.), but evidently the chlorine content of the atmosphere at 3,000 m. is by no means negligible.

Summary of Results.

It is impossible with the data available to get even an approximate figure for the amount of salt transported per annum, as we do not know what goes on in the higher regions of the atmosphere. To get a rough idea of the quantities involved, let us assume that all the salt transported is carried in the lowest 100 metre layer,—in which we make a large negative error,—and that the amount of salt per unit volume throughout this layer is the same as that found 75 c.m. above the ground,—in which we probably make a positive error less than the first, and let us find how much salt would be transported per annum over an area equal to the drainage area of the Sambhar Lake. If we take the average of the aspirator determinations at 75 c.m. from 12th May till the break of the rains, we find it to be 0·0000885 g. per m^3. at 0°C. and 760 m.m.—say 0·0000774 at 35°C. and 750 m.m. The Sambhar catchment area is about 2,200 square miles; assuming i circular, the diameter is 85,000 metres. If we assume the transport of salt to go on for 12 hours a day for four months at the average speed recorded during the experiments in question (23·6 miles per hour), we find 23·6 × 1,609 × 4 × 30 × 12 metres to be the length, as it were, of the prism of air in question; its width is 85,000 metres; its height 100 metres. We have, therefore, for the amount of salt transported 85,000 × 23·6 × 1,609 × 4 × 30 × 12 × 100 × 0·0000774 grams = 36,000 metric tons. If we take a front of 300 k.m., we find that 130,000 tons would be transported into Rajputana each hot weather.

As the speed of the wind, more especially in the neighbourhood of Sambhar than at Pachbadra, falls off to a very gentle breeze at night the salt in suspension in the air has a chance of being deposited; once deposited, it is less likely to be retransported than at places nearer the coast where the winds are considerably stronger.

1 *Comptes Rendus*, CXII (1891), 448.
2 *Geog. Jour.* XXXI, p. 402.

Sometimes in the hot weather, the wind is sufficiently strong to traverse the distance from the Rann to Sambhar in 12 hours, but, as a rule, the particles must be transported by stages. Let us assume, postulating as before no precision, that half of the salt in suspension over the Sambhar drainage area when the wind falls in the evening is precipitated overnight and that none is precipitated in the daytime. In the four hot weather months this would amount to some 3,000 tons, and in 18,000 years to 55,000,000 tons, the amount contained in the upper 12 feet of the Sambhar silt. The figures, of course, have no precise value, but they give some crude idea of the quantities involved.

Application of explanation to ancient rock-salt deposits.

The results have an important bearing on current theories regarding the origin of the numerous rock-salt deposits that are found in strata of widely varying ages in different parts of the world. Such deposits are generally regarded as due, either to the drying up of large inland lakes and consequent concentration of their saline constituents, or to the similar concentration of bodies of sea-water cut off wholly or partially from the general body of the ocean. The latter explanation is more generally adopted to account for the thick and repeated beds of salt with alternations of gypsum. As wide desert areas are commonly areas of low barometric pressure, and towards which consequently strong winds blow from outside, the theory of Posepny may be of wide application. Many of the rock-salt deposits of the world are accompanied by signs of desert phenomena, but these do not necessarily imply that the salt deposits were not formed by the concentration of bodies of sea-water, for obviously the one condition necessary for the rapid evaporation of partially isolated basins of sea-water is a climate so dry that there are few or no fresh-water rivers entering such basins. Deposits of salt laid down in such basins, must, therefore, be found within close range of areas affected by desert conditions, although the salt deposits are not necessarily laid down within the desert area in the manner exemplified in the Rajputana region.

Though it has been proved that large quantities of salt are carried into Rajputana by the wind, this explanation cannot be applied widely to the rock-salt deposits of the past without danger of confusing cause and effect. In the great Persian deserts—the Dasht-i-Kavir and Dasht-i-Lut—there is now possibly an influx

of salt-bearing wind from the north-west and from the south-east; but the topography of the country suggests that this great belt of desert regions is a part of the Caspian depression in which a remnant of the ocean is in course of concentration; the salt marshes of the Russian steppes are probably the north-westward continuation of this depression. In the Persian area, therefore, it is not necessarily the desert conditions that have caused the accumulation of salt, but the salt left in other ways has probably assisted in the development of desert phenomena.

The connection between desert phenomena and the British Triassic rock-salt deposits has recently been reviewed and developed by the late Mr. J. Lomas.[1] Some of the features characteristic of the British Trias as well as of other rock-salt bearing formations which have been recognized in Rajputana have been mentioned in the previous pages. It is necessary, however, to make special mention of the gypsum which so constantly accompanies rock-salt. This mineral not only occurs as isolated crystals in saline lake silts, but in parts of Rajputana, as at Mangalore in Jodhpur State and at Jamsar in Bikaner, it forms extensive deposits 3 to 5 feet thick, sufficiently pure to permit of wholesale quarrying. An occurrence of gypsum not unlike these in Rajputana is mentioned by Munzinger[2] in the great salt basin to the east of the Abyssinian mountains.

Nodular carbonate of lime (*kankar*) occurs commonly in the Rajputana desert region, but as this substance is also common in alluvial deposits like those of the Indo-Gangetic plain, it is not peculiar to desert regions.

Conclusions.

It has now been shown by actual observation during the hot weather that large quantities of sodium chloride in the form of fine dry dust are carried into the desert region of Rajputana from the south-south-west. Concluding from the daily observations made at Pachbadra (25° 55′ N., 72° 11′ E.) during the hot weather of 1908, the amount of salt passing a front 300 k.m. broad and 100 m. high during the four hot weather months might be

[1] *Rep. Brit. Assoc.*, 1906, 574, and *Proc. Liverpool Geol. Soc.*, 1906-07, pp. 172-197.

[2] *Geogr. Jour.*, 1869, p. 188.

indicated as 130,000 tons. The hot weather of 1908 was a season of unusually weak winds, and this figure (which has little more than qualitative value) is probably well below the annual average influx of salt dust.

When it is known that these hot winds blow steadily towards the north-north-east for three or four months every year, that they are strongest (often attaining the speed of gales) during the day-time when the salt dust is dried by the scorching sun under a cloudless sky, that there is no reflux and very little variation in direction, with a gradually diminishing speed as the heart of the desert is approached, and that the period of hot, dry, southerly winds is followed always by a downpour of rain, with the formation of a lake in each small area of internal drainage in the Rajputana desert, it is easy to account for the great accumulations of saline silt which are left after the annual desiccation of the salt lakes.

These winds from the south-south-west blow over the arm of the sea known as the Rann of Cutch, which is covered with a layer of white salt during the hot, dry season. Every disturbance of this crust by pedestrians and animals helps to form the salt dust which is wafted away towards Rajputana. The winds blow strongly in the daytime, with a lull at nights, but the movement is all in one direction at the time of year when the dust is dry and can be carried most easily; and there is no set-back until after the monsoon period of rain when all the finely divided salt dust that may have reached the heart of the desert is washed into the hollows occupied by brine lakes. The strength of these winds is indicated by the fact that small foraminifera have been carried bodily (not rolled) as far as 500 miles inland from the coast of Cutch.

An idea of the quantities of salt to be accounted for has been obtained by a special examination of the Sambhar Lake: the silt of this lake partly fills a depression in the Aravalli schist "country"; it has been shown by two borings that the silt is about 70 feet thick in places, and, as the result of detailed sampling at regular intervals, it has been shown that the uppermost 12 feet of this silt over an area of 68 square miles includes 55,000,000 tons of sodium chloride. There are many other smaller salt lakes of the Sambhar type on the Rajputana highlands, and there may be many such bodies of silt buried under the mantle of sand.

We consider that the action of the wind alone is sufficient to account for the large accumulations of salt in Rajputana. The instance is one of special importance from the circumstance that on the Rajputana highlands no other explanation offered will account for any but unimportant quantities of salt; there are no inflowing large rivers; there are no traces of ancient rock-salt deposits; no known saline springs; no likelihood of subterranean water rising to the surface; no probable connection throughout most of the area lying on the crystalline schists with the water which is possibly percolating underground from the lower-lying Punjab plains towards the still lower depression of the Indus valley.

While admitting that rock-salt deposits may be formed in other ways also, our observations in Rajputana go far to strengthen the evidences gathered by the late J. Lomas and others to show that many rock-salt deposits, like those in the British Trias, are dependent on desert conditions. Large desert areas are regions of indraught during the hot dry seasons when any salt available is easily pulverised. Where there are regions of internal drainage the salt becomes "fixed" in local hollows after rain. In the Rajputana salt-lake region we find deposits of gypsum, nodular limestone, and plano-convex lenticular masses of calcareous mud stained black with ferrous sulphide, which, on oxidation, would give rise to the red colour so characteristic of the marls and sands associated with rock-salt deposits.

The well-known estimate of the age of the ocean made by Prof. J. Joly included a ten per cent. correction due to the sea salt carried inland by winds and brought down by rain to add to the quantity carried to the ocean by rivers. References to the salt carried inland by sea-breezes have generally assumed that the principal quantities leave the ocean as fine spray; but it appears from our observations that under special conditions like those in Western India, where a desert region forms the hinterland of a salt-incrusted temporary arm of the sea, far larger quantities of sea salt may be carried inland as finely divided dust. It is impossible, however, to say from our results that Prof. Joly's allowance for sea-salt in river-waters should be materially increased.

The process by which the salt is formed in the Rann of Cutch tends to eliminate the rarer and more soluble magnesium and potassium salts leaving the wind-borne chloride to be more

purely that of sodium than would be the result of an inland transportation of simple sea spray. The iodine and bromine in the Sambhar brines are found to be in a smaller ratio to the chlorine than in sea-water, possibly for a similar reason, but these two halogens bear just the same ratio to one another as in the sea.

MISCELLANEOUS NOTES.

Corrective note on the fossil described under the provisional name "Twingonia," from the Pegu beds ("Miocene") of Burma.

It has been found by Mr. Bankim Behari Gupta, Museum Assistant, that the fossil temporarily named "Twingonia" and described in *Rec., Geol. Surv. India,* Vol. XXXVI, Part 3, pp. 138—139, as resembling more than anything else some foraminifer allied to *Orbitoides,* is identical with some fish otoliths discovered by Dr. Noetling. The form I described has been taken for a nummulite and does bear an accidental resemblance in shape and occasionally in structure to the *Nummulinidæ.* Dr. Noetling, seemingly, did not at the time consider it of sufficient importance to warrant a description, and merely referred to it as "*Otolithus* sp." (*Palæont. Ind.,* new series, Vol. I, Part 3, p. 376), stating that it apparently differed from any of the forms described by Dr. Koken in his monograph (*Zeits. d. Deutsch. Geol. Gesells.,* Vol. XXXVI, 1884, p. 500). His two figures are small, and owing to the paucity of external features in the fossil, convey very little impression of its characteristics. By a regrettable oversight I must have overlooked his type-specimen. The name "Twingonia" was never intended to have any necessarily generic significance, and, pending further research, might still be used provisionally with advantage. Since attention was drawn to it, specimens have been reported from many localities in Burma.

[E. H. PASCOE.]

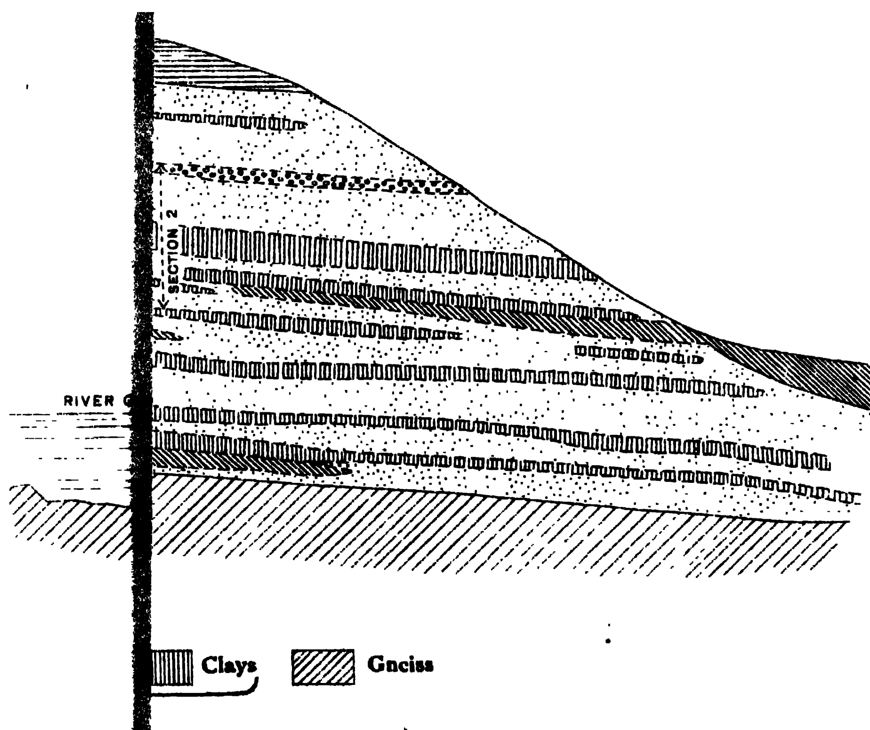
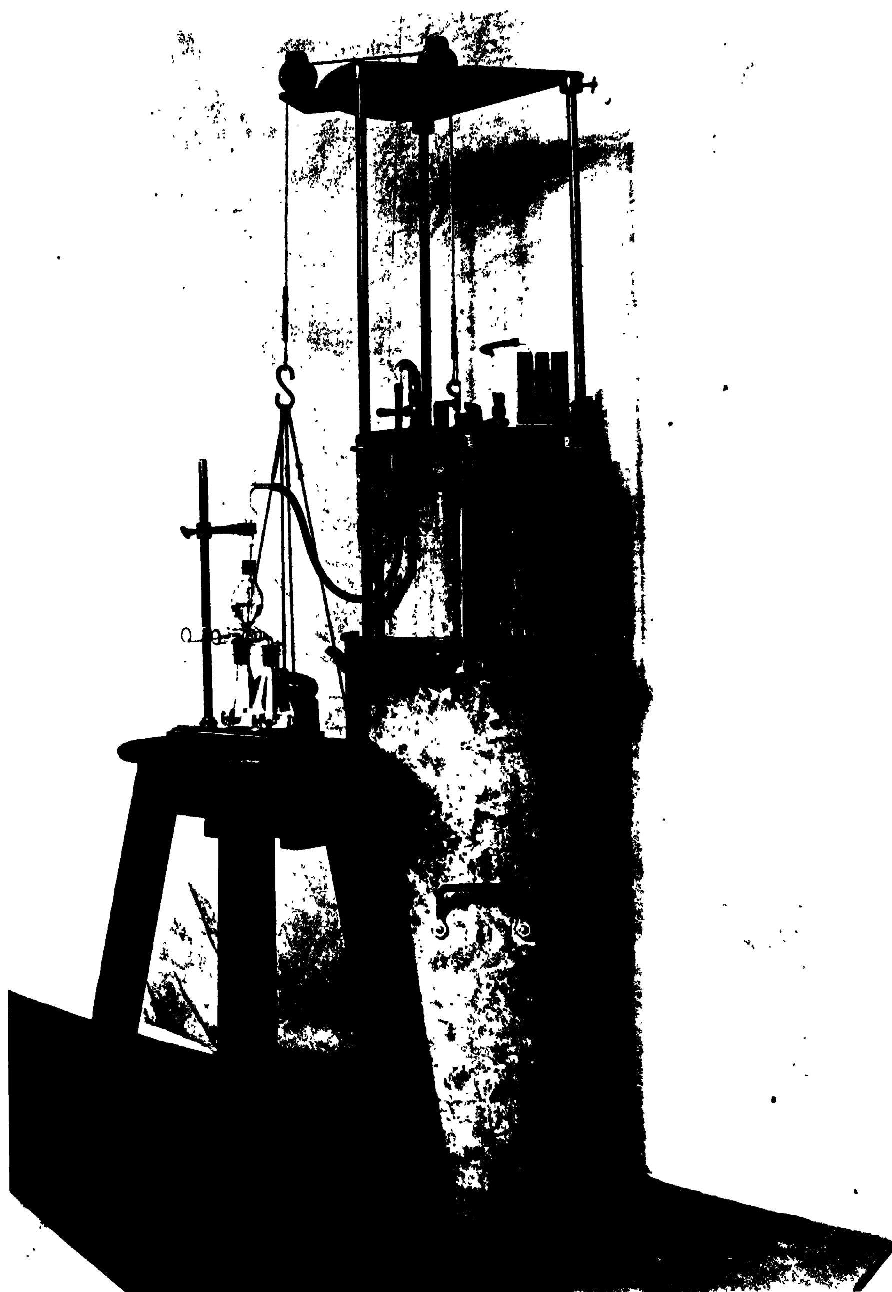

SECTION 2
RIVER
Clays
Gneiss

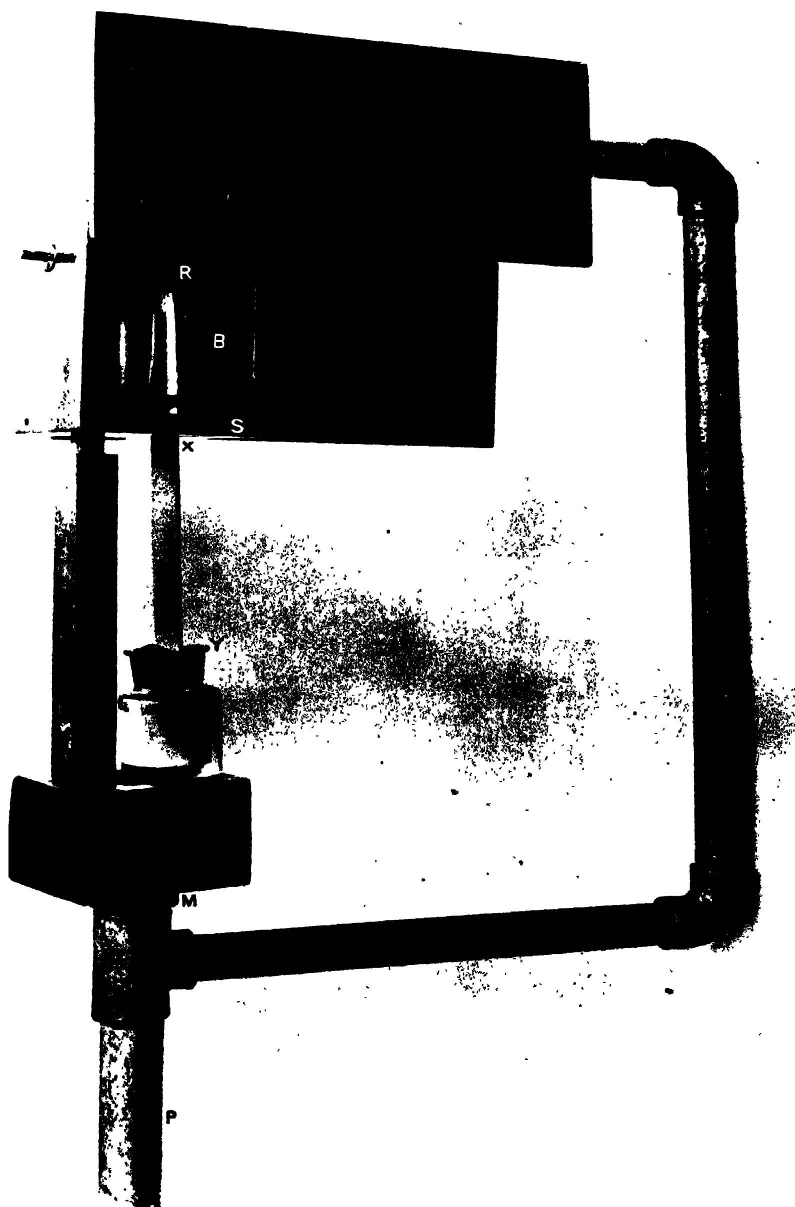


Photo. by M. Stuart

FIG 1 SHOWING OCCURRENCE OF BED OF WHITE CLAY, 3 FEET THICK, IN WHITE DAMUDA SANDSTONE, BORA GHAT.






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Part 2 (*out of print*).—Rocks of the Lower Godavari. 'Atgarh Sandstones' near Cuttack. Fossil floras in India. New or rare mammals from the Siwaliks. Arvali series in North-eastern Rajputana. Borings for coal in India. Geology of India.

Part 3 (*out of print*).—Tertiary zone and underlying rocks in North-west Punjab. Fossil floras in India. Erratics in Potwar. Coal explorations in Darjiling district. Limestones in neighbourhood of Barakar. Forms of blowing-machine used by smiths of Upper Assam. Analyses of Raniganj coals.

Part 4.—Geology of Mahanadi basin and its vicinity. Diamonds, gold, and lead ores of Sambalpur district. 'Eryon Comp. Barrovensis,' McCoy, from Sripermatur group near Madras. Fossil floras in India. The Blaini group and 'Central Gneiss' in Simla Himalayas. Tertiaries of North-West Punjab. Genera Chœromeryx and Rhagatherium.

VOL. XI, 1878.

Part 1.—Annual report for 1877. Geology of Upper Godavari basin, between river Wardha and Godavari, near Sironcha. Geology of Kashmir, Kishtwar, and Pangi. Siwalik mammals. Palæontological relations of Gondwana system. 'Erratics in Punjab.'

Part 2.—Geology of Sind (second notice). Origin of Kumaun lakes. Trip over Milam Pass, Kumaun. Mud volcanoes of Ramri and Cheduba. Mineral resources of Ramri, Cheduba and adjacent islands.

Part 3.—Gold industry in Wynaad. Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

Part 4.—Geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

VOL. XII, 1879

Part 1.—Annual report for 1878. Geology of Kashmir (third notice). Siwalik mammalia. Siwalik birds. Tour through Hangrang and Spiti. Mud eruption in Ramri Island (Arakan). Braunite, with Rhodonite, from Nagpur, Central Provinces. Palæontological notes from Satpura coal-basin. Coal importations into India.

Part 2.—Mohpani coal-field. Pyrolusite with Psilomelane at Gosalpur, Jabalpur district. Geological reconnaissance from Indus at Kushalgarh to Kurram at Thal on Afghan frontier. Geology of Upper Punjab.

Part 3.—Geological features of northern Madura, Pudukota State, and southern parts of Tanjore and Trichinopoly districts included within limits of sheet 80 of Indian Atlas. Cretaceous fossils from Trichinopoly district, collected in 1877-78. Sphenophyllum and other Equisetaceæ with reference to Indian form Trizygia Speciosa, Royle (Sphenophyllum Trizygia, Ung.). Mysorin and Atacamite from Nellore district. Corundum from Khasi Hills. Joga neighbourhood and old mines on Nerbudda.

Part 4.—'Attock Slates' and their probable geological position. Marginal bone of undescribed tortoise, from Upper Siwaliks, near Nila, in Potwar, Punjab. Geology of North Arcot district. Road section from Murree to Abbottabad.

VOL. XIII, 1880.

Part 1.—Annual report for 1879. Geology of Upper Godavari basin in neighbourhood of Sironcha. Geology of Ladak and neighbouring districts. Teeth of fossil fishes from Ramri Island and Punjab. Fossil genera Nöggerathia, Stbg., Nöggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Fossil plants from Kattywar, Shekh Budin, and Sirgujah. Volanic foci of eruption in Konkan.

Part 2.—Geological notes. Palæontological notes on lower trias of Himalayas. Artesian wells at Pondicherry, and possibility of finding sources of water-supply at Madras.

Part 3.—Kumaun lakes. Celt of palæolithic type in Punjab. Palæontological notes from Karharbari and South Rewa coal-fields. Correlation of Gondwana flora with other floras. Artesian wells at Pondicherry. Salt in Rajputana Gas and mud eruptions on Arakan coast on 12th March 1879 and in June 1843.

Part 4.—Pleistocene deposits of Northern Punjab, and evidence they afford of extreme climate during portion of that period. Useful minerals of Arvali region. Correlation of Gondwana flora with that of Australia coal-bearing system. Reh or alkali soils and saline well waters. Reh soils of Upper India. Naini Tal landslip, 18th September 1880.

VOL. XIV, 1881.

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts. Siwalik carnivora. Siwalik group of Sub-Himalayan region. South Rewah Gondwana basin. Ferruginous beds associated with basaltic rocks of north-eastern Ulster, in relation to Indian laterite. Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on lower trias of Himalayas.' Mammalian fossils from Perim Island.

Part 2.—Nahan-Siwalik unconformity in North-Western Himalaya. Gondwana vertebrates. Ossiferous beds of Hundes in Tibet. Mining records and mining record office of Great Britain; and Coal and Metalliferous Mines Act of 1872 (England). Cobaltite and danaite from Khetri mines, Rajputana; with remarks on Jaipurite (Syepoorite). Zinc-ore (Smithsonite and Blende) with barytes in Karnul district, Madras. Mud eruption in island of Cheduba.

Part 3.—Artesian borings in India. Oligoclase granite at Wangtu on Sutlej, North-West Himalayas. Fish-palate from Siwaliks. Palæontological notes from Hazaribagh and Lohardagga districts. Fossil carnivora from Siwalik hills.

Part 4.—Unification of geological nomenclature and cartography. Geology of Arvali region, central and eastern. Native antimony obtained at Pulo Obin, near Singapore. Turgite from Juggiapett, Kistnah district, and zinc carbonate from Karnul, Madras. Section from Dalhousie to Pangi, *viâ* Sach Pass. South Rewah Gondwana basin. Submerged forest on Bombay Island.

Vol. XV, 1882.

Part 1 (out of print).—Annual report for 1881. Geology of North-West Kashmir and Khagan. Gondwana labyrinthodonts. Siwalik and Jamna mammals. Geology of Dalhousie, North-West Himalaya. Palm leaves from (tertiary) Murree and Kasauli beds in India. Iridosmine from Noa-Dihing river, Upper Assam, and Platinum from Chutia Nagpur. On (1) copper mine near Yongri hill, Darjiling district; (2) arsenical pyrites in same neighbourhood; (3) koalin at Darjiling. Analyses of coal and fire-clay from Makum coal field, Upper Assam. Experiments on coal of Pind Dadun Khan. Salt-range, with reference to production of gas, made April 29th, 1881. Proceedings of International Congress of Bologna.

Part 2 (out of print).—Geology of Travancore State. Warkilli beds and reported associated deposits at Quilon, in Travancore. Siwalik and Narbada fossils. Coal bearing rocks of Upper Rer and Mand rivers in Western Chutia Nagpur. Pench river coal-field in Chhindwara district, Central Provinces. Borings for coal at Engsein, British Burma. Sapphires in North-Western Himalaya. Eruption of mud volcanoes in Cheduba.

Part 3.—Coal of Mach (Much) in Bolan Pass, and of Sharigh on Harnai route between Sibi and Quetta. Crystals of stilbite from Western Ghats, Bombay. Traps of Darang and Mandi in North Western Himalayas. Connexion between Hazara and Kashmir series. Umaria coal field (South Rewah Gondwana basin). Daranggiri coal-field, Garo Hills, Assam. Coal in Myanoung division, Henzada district.

Part 4 (out of print).—Gold-fields of Mysore. Borings for coal at Beddadanol, Godavari district, in 1874. Supposed occurrence of coal on Kistna.

Vol. XVI, 1883.

Part 1.—Annual report for 1882. Richthofenia, Kays (Anomia Lawrenciana, Koninck). Geology of South Travancore. Geology of Chamba. Basalts of Bombay.

Part 2.—Synopsis of fossil vertebrata of India. Bijori Labyrinthodont. Skull of Hippotherium antilopinum. Iron ores, and subsidiary materials for manufacture of iron, in north-eastern part of Jabalpur district. Laterite and other manganese-ore occurring at Gosulpore, Jabalpur district. Umaria coal-field.

Part 3.—Microscopic structure of some Dalhousie rocks. Lavas of Aden. Probable occurrence of Siwalik strata in China and Japan. Mastodon angustidens in India. Traverse between Almora and Mussooree. Cretaceous coal-measures at Borsora, in Khasia Hills, near Laour, in Sylhet.

Part 4.—Palæontological notes from Daltonganj and Hutar coal-fields in Chota Nagpur. Himalayas. Traverse through Eastern Khasia, Jaintia, and North Cachar Hills ture of some Sub-Himalayan rocks of tertiary age. Geology of Jaunsar and Lower Altered basalts of Dalhousie region in North-Western Himalayas. Microscopic struc-Native lead from Maulmain and chromite from the Andaman Islands. Fiery eruption from one of mud volanoes of Cheduba Island, Arakan. Irrigation from wells in North-Western Provinces and Oudh.

Vol. XVII, 1884.

Part 1.—Annual report for 1883. Smooth-water anchorages or mud-banks of Narrakal and Alleppy on Travancore coast. Billa Surgam and other caves in Kurnool district. Geology of Chuari and Sihunta parganas of Chamba. Lyttonia, Waagen, in Kuling series of Kashmir.

Part 2.—Earthquake of 31st December 1881. Microscopic structure of some Himalayan granites and gneissose granites. Choi coal exploration. Re-discovery of fossils in Siwalik beds. Mineral resources of the Andaman Islands in neighbourhood of Port Blair. Intertrappean beds in Deccan and Laramie group in Western North America.

Part 3 (out of print).—Microscopic structure of some Arvali rocks. Section along Indus from Peshawar Valley to Salt-range. Sites for boring in Raigarh-Hingir coal-field (first notice). Lignite near Raipore, Central Provinces. Turquoise mines of Nishâpûr, Khorassan. Fiery eruption from Minbyin mud volcano of Cheduba Island, Arakan. Laugrin coal-field, South-Western Khasia Hills. Umaria coal-field.

Part 4.—Geology of part of Gangasulan pargana of British Garhwal. Slates and schists imbedded in gneissose granite of North-West Himalayas. Geology of Takht-i-Suleiman. Smooth-water anchorages of Travancore coast. Auriferous sands of the Subansiri river. Pondicherry lignite, and phosphatic rocks at Musuri. Billa Surgam caves.

VOL. XVIII, 1885.

Part 1.—Annual report for 1884. Country between Singareni coal-field and Kistna river. Geological sketch of country between Singareni coal-field and Hyderabad. Coal and limestone in Doigrung river near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field notes.

Part 2.—Fossiliferous series in Lower Himalaya, Garhwal. Age of Mandhali series in Lower Himalaya. Siwalik camel (Camelus Antiquus, nobis ex Falc. and Caut. MS.). Geology of Chamba. Probability of obtaining water by means of artesian wells in plains of Upper India. Artesian sources in plains of Upper India. Geology of Aka Hills. Alleged tendency of Arakan mud volcanoes to burst into eruption most frequently during rains. Analyses of phosphatic nodules and rock from Mussooree.

Part 3.—Geology of Andaman Islands. Third species of Merycopotamus. Percolation as affected by current. Pirthalla and Chandpur meteorites. Oil-wells and coal in Thayetmyo district, British Burma. Antimony deposits in Maulman district. Kashmir earthquake of 30th May 1885. Bengal earthquake of 14th July 1885.

Part 4.—Geological work in Chhattisgarh division of Central Provinces. Bengal earthquake of 14th July 1885. Kashmir earthquake of 30th May 1885. Excavations in Billa Surgam caves. Nepaulite. Sabetmahet meteorite.

VOL. XIX, 1886.

Part 1.—Annual report for 1885. International Geological Congress of Berlin. Palæozoic Fossils in Olive group of Salt range. Correlation of Indian and Australian coal-bearing beds. Afghan and Persian Field-notes. Section from Simla to Wangtu, and petrological character of Amphibolites and Quartz Diorites of Sutlej valley.

Part 2.—Geology of parts of Bellary and Anantapur districts. Geology of Upper Dehing basin in Singpho Hills. Microscopic characters of eruptive rocks from Central Himalayas. Mammalia of Karnul Caves. Prospects of finding coal in Western Rajputana. Olive group of Salt-range. Boulder-beds of Salt-range. Gondwana Homotaxis.

Part 3.—Geological sketch of Vizagapatam district, Madras. Geology of Northern Jesalmer. Microscopic structure of Malaini rocks of Arvali region. Malanjkhandi copper-ore in Balaghat district, C. P.

Part 4 (out of print).—Petroleum in India. Petroleum exploration at Khátan. Boring in Chhattisgarh coal-fields. Field-notes from Afghanistan: No. 3, Turkistan. Fiery eruption from one of mud volcanoes of Cheduba Island, Arakan. Nammianthal aerolite. Analysis of gold dust from Meza valley, Upper Burma.

VOL. XX, 1887.

Part 1.—Annual report for 1886. Field-notes from Afghanistan: No. 4. from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traversed through Jaunsar-Bawar and Tiri-Garhwal. Geology of Garo Hills. Indian image-stones. Soundings recently taken off Barren Island and Narcondam. Talchir boulder-beds. Analysis of Phosphatic Nodules from Salt-range, Punjab.

Part 2.—Fossil vertebrata of India. Echinoidea of cretaceous series of Lower Narbada Valley. Field-notes: No. 5—to accompany geological sketch map of Afghanistan and North-Eastern Khorassan. Microscopic structure of Rajmahal and Deccan traps. Dolerite of Chor. Identity of Olive series in east with speckled sandstone in west of Salt-range in Punjab.

Part 3.—Retirement of Mr. Medlicott. J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section I. Geology of Simla and Jutogh. 'Lalitpur' meteorite.

Part 4.—Points in Himalayan geology. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section II. Iron industry of western portion of Raipur. Notes on Upper Burma. Boring exploration in Chhattisgarh coal-fields. (Second notice). Pressure Metamorphism, with reference to foliation of Himalayan Gneissose Granite. Papers on Himalayan Geology and Microscopic Petrology.

VOL. XXI,

Part 1.—Annual report for 1887. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section III. Birds'-nest of Elephant Island, Mergui Archipelago. Exploration of Jessalmer, with a view to discovery of coal. Facetted pebble from boulder bed ('speckled sandstone') of Mount Chel in Salt-range, Punjab. Nodular stones obtained off Colombo.

Part 2.—Award of Wollaston Gold Medal, Geological Society of London, 1888. Dharwar System in South India. Igneous rocks of Raipur and Balaghat, Central Provinces. Sangar Marg and Mehowgale coal-fields, Kashmir.

Part 3.—Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' Pre-tertiary sedimentary formations of Simla region of Lower Himalayas.

Part 4.—Indian fossil vertebrates. Geology of North-West Himalayas. Blown-sand rock sculpture. Nummulites in Zanskar. Mica traps from Barakar and Raniganj.

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RECORDS OF
THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1909. [November.

REPORT ON THE GEOLOGY OF SARAWAN, JHALAWAN, MEKRAN AND THE STATE OF LAS BELA, CONSIDERED PRINCIPALLY FROM THE POINT OF VIEW OF ECONOMIC DEVELOPMENT.

By E. W. VREDENBURG, *Assistant Superintendent, Geological Survey of India.*

(With Plates 8 to 12.)

I.—GEOLOGICAL SUMMARY.

1.—INTRODUCTION.

THANKS to the kind assistance tendered by Major Showers, Captain MacConaghey, and Mr Brett, Political Officers of the Kelat Agency, and by the rulers and officials of the States of Kelat and Las Bela, I have been able, together with my colleague Mr. Tipper, during the winter of 1905-1906, to visit a very vast extent of country regarding the geology of which very little was known up to the present day.

The following summary is a reprint of a report submitted to the Government of the Baluchistan Agency, with a view to draw attention to certain matters that might be of economic importance. As it also contains a great deal that is of scientific interest, it is reproduced in these *Records*, pending the publication of a more detailed account which is being prepared for the *Memoirs*.

The vast extent of the country which I surveyed within the limited time of about four months precluded the possibility of detailed prospecting. All I can do is to indicate in which particular regions further research is specially advisable. For instance, in

the case of coal, I have been able to establish that the geological formation containing this mineral occurs only in a comparatively restricted area of the Sarawan district. The limits of the coal-bearing beds being thus ascertained, it becomes a comparatively easy task for an expert to ascertain the quality and extent of the coal-seams in this relatively small area. My own examination of the coalfield had to be necessarily a cursory one, otherwise it would have encroached upon the time needed for the examination of other areas. The same thing applies to every part of the country visited, and therefore, the paucity of the minerals actually seen does not necessarily imply the mineral poverty of the country. The method which I pursued is the only systematic one in researches of this kind: by means of the general survey just completed, it will now be possible to attempt prospecting operations in restricted areas.

2.—MAIN DIVISIONS OF THE AREA.

The area is divided into an eastern and a western region by an irregular north and south line roughly coinciding with longitude 66° 15′ E. The western region is almost entirely occupied by a monotonous series of shales or clay-shales and sandstones known in the publications of the Geological Survey of India as Kojak or Mekran beds which correspond principally with the oligocene "flysch" of Europe. This western region may be spoken of as the "flysch region." The eastern region exhibits a far more varied geological sequence and consists of rocks ranging in age through a vast series of successive geological formations, all of which are remarkable for containing vast thicknesses of limestone. This area may be spoken of therefore as the "calcareous region."

In both regions, the strata have been folded into a succession of anticlines separated by synclines. In the western or "flysch" area, excepting the neighbourhood of the sea-coast, the flexures are generally much sharper and much more numerous than in the eastern region. This is due partly to the somewhat greater degree of compression that has affected the rocks of that western region, and largely to the pliable nature of their shaly layers as compared with the unyielding limestone masses of the eastern area, which, instead of becoming crumpled into innumerable small sharp folds, have risen into great dome-shaped bulges often several miles

across. These differences in composition and structure have exerted a considerable influence in determining the physical features of the two regions.

3.—THE CALCAREOUS REGION.

The eastern region including the greater part of Sarawan, Jhalawan and Las Bela, is constituted by a vast thickness of sedimentary rocks ranging in age from Carboniferous to pliocene. As already mentioned, a considerable proportion of these rocks consists of limestones, those of the oligocene (Nari series), eocene (Khirthar series), and especially of the Jurassic, being particularly massive. These Jurassic limestones include a thickness of several thousand feet of limestone of which the newer portion, middle Jurassic in age, is extremely thick-bedded, and dark-grey in colour, while the older portion, whose age is Liassic, consists of less massive layers, very distinctly bedded, and of a still darker grey tint, sometimes nearly black.

These Jurassic limestones constitute the leading features of the orography of this area. The tallest and most massive mountains are huge anticlinal bulges of Jurassic limestones from which the overlying strata have been denuded away. They have the shape of elongated domes irregularly elliptical in plan, the longer axis striking more commonly approximately north and south, or, less frequently, somewhat at right angles to this direction. Surrounding these dome-shaped mountains, there is usually a ring of less lofty but very steep ridges constituted by regularly bedded limestones, which are as hard and compact as those of the domes themselves but whose aggregate thickness is always much less; they are of lower Cretaceous age, and normally overlie the massive Jurassic limestones; their situation at the periphery of the Jurassic domes is due to their having been denuded away from the central loftiest portion of those structures. Their concentric disposition with reference to the massive domes is very noticeable on a map, while their clear white or red colours contrast curiously with the dark tinge of the huge limestone masses which they encircle.

The steep slopes of the Jurassic limestone hills generally coincide with the angle of dip of the strata. After laying bare the surface of the massive Jurassic beds by removal of the somewhat thinner-bedded rocks overlying them, denudation has almost come to a

standstill. Except in the few cases where they are cut through by deep and narrow rift-like river gorges, these Jurassic rocks have scarcely suffered from denudation or erosion. This accounts for the uniform appearance of their inaccessible slopes corresponding with the surface of bedding of the high-dipping strata. The almost continuous barrier of steep ridges of cretaceous limestones encircling them contributes to render them still more difficult of access.

Amongst the most conspicuous hills of Jurassic limestone may be mentioned the Chehiltan and Koh-i-Maran in Sarawan, consisting of Middle Jurassic limestones, Anjiro and Sumbaji in Jhalawan, consisting of Liassic beds.

The main channels of drainage have established themselves principally in the synclinal valleys intervening between these massive Jurassic domes or ridges. The Shirinab river, the Mula, the Hab, the Porali, the Bolan, have their courses situated mainly along synclines.

A disposition of this sort, with the upheaved bulges forming hills and the intervening troughs valleys, is what one would most naturally expect *a priori* in any country where the strata have been folded and upheaved. Yet it is by no means one generally met with, at least not in countries favoured by a sufficiently abundant rainfall. For, although a disposition of this sort must have naturally originated in every folded district immediately after the folding and upheaval had taken place, it did not usually persist: the axes of the anticlines, by the very reason of their greater elevation, became exposed to denudation more that the intervening troughs. Moreover, the rocks wedged in along the synclines became more indurated by compression than those in the anticlinal bulges which, instead of being compressed, had a tendency to expand towards the free surface and to become fissured. Consequently, denudation proceeds at a much faster rate along the anticlines than along the synclines, with the final result of a complete reversal of the original topography, the anticlines being occupied by river-valleys, between which the rocks forming the synclines are left standing as ridges. The well-known principles are here referred to in order to emphasize the peculiar physical features of the calcareous zone. The absence of any instances of a reversal of the topography in the calcareous districts of Baluchistan, follows from a twofold cause: the scantiness of the rainfall, and the preponderance of

limestones. In consequence of the deficient rainfall, denudation has proceeded far more slowly than in countries better favoured in that respect, and the calcareous constitution of the rocks still further aggravates the backward condition of the topography: owing to the slightly solvent action of rain-water upon limestone, the water finds its way through fissures, and thus excavates subterranean channels by means of which it sinks at once to the low level of the river beds deeply encased in narrow gorges, and cannot, therefore, gather sufficient volume on the hill-slopes to produce any appreciable erosion. The only way in which the surface of such a calcareous country can become noticeably transformed, is by the collapse of the caverns through which the streams circulate underground, but where the rainfall is as scanty as in this part of Baluchistan, the caverns remain narrow, and their roof shows no tendency to fall in.

The greater part of the eastern or calcareous region, is, as above explained, occupied by numerous anticlinal bulges of Jurassic rocks. There are two principal groups of hills built up of Jurassic limestones. The first group occupies nearly the whole width of Sarawan from the neighbourhood of the Quetta region southwards up to the latitude of Manguchar. From Manguchar it continues south-westwards with diminished breadth, the Jurassic beds becoming gradually concealed by overlying deposits to the south-west of Kelat. Throughout this region, the strike of the ridges is very regular, about 15° to 20° east of north. The loftiest peaks of the Sarawan Jurassics are those of Chehiltan and Koh-i-Maran.

The second group of Jurassic anticlines occupies nearly the whole breadth of northern Jhalawan from east to west about Zahri, Bhagwana and the Mula Pass. From Bhagwana it divides into two principal branches, one striking southwards towards Khozdar and Wad, and continuing east of the Porali river and of the plain of Las Bela up to near the sea-coast. The second branch strikes south-west towards Kodak, Nal, and Jebri, and finally disappears beneath newer rocks before reaching Wasar. This western branch might be regarded as a prolongation of the Sarawan group of Jurassic ridges that gradually dwindles to the south-west of Kelat. There is also a somewhat interrupted series of narrow outcrops extending north-east from the Mula Pass, towards the Bolan Pass, the northernmost prolongations of which merge into the eastern margin of the Sarawan group.

The strike of the ridges constituting the Jurassic group of Jhalawan is not so regular as in Sarawan. The south-eastern extension towards Jebri, and the north-western extension towards the Bolan Pass strike more or less east of north, conforming themselves, therefore, to the general direction of strike of the Sarawan group. In the south-eastern group, the strike varies from south to a little east of south. In northern Jhalawan, that is in the region of Zahri, Bhagwana, the Mula Pass, where the Jurassic ridges extend almost right across the province, the strike curves rather rapidly from north-east, at the western margin of the district to south-east at the eastern margin, while in the middle of the area it is mostly east and west: the different directions of strike curiously interfere with one another in this part of the district, curtailing the length of the ridges in such a manner that they sometimes become almost circular domes.

Wedged in between the Sarawan and the Jhalawan series of anticlinal bulges is an elevated plateau extending diagonally from north-east to south-west across southern Sarawan and northern Jhalawan. There is no general name to designate this well marked topographical feature, though various parts of it are known by local names such as Luddok and Sarun designating the cliffs forming the north-eastern edge of the plateau, Shamo, the cliffs of its south-eastern edge, Melabi, its north-western spur, Harboi, a lofty ridge south-east of Kelat, with the highest peak of the plateau (9,830 feet). This lofty plateau consists of massive limestones, but, both in age and in structure, it differs from the surrounding anticlinal ridges of Jurassic limestones. It consists of eocene rocks resting upon the Jurassic and Cretaceous, and, instead of being an anticlinal bulge, it is, mainly, an elevated shallow synclinal trough surrounded by a slightly raised rim. The edges of the plateau are tall craggy cliffs of limestone, usually with an underscarp of shaly beds. The massive limestone forming this immense plateau is a nummulitic limestone of white or pale-buff, or pale-grey colour, belonging to the series described in the publications of the Geological Survey of India as Upper Khirthar or as Spintangi.

East and north-east of the great plateau area it forms other scarped synclinal ridges striking a few degrees east of north. The Upper Khirthar limestones are also largely developed all along the eastern margin of the calcareous region, south of the Mula Pass, especially in the Khirthar range, where their vast thickness is still

further reinforced by an enormous mass of overlying limestones white or brown in colour, of oligocene age, constituting part of the Nari Series of Indian Geological nomenclature. From Gidar and Nal up to the northern edge of the plain of Las Bela, the limestone ranges forming the western margin of the calcareous region, also consist of an enormous thickness of these massive Nari limestones.

Except where these Tertiary limestones (eocene or oligocene) rest directly upon older Cretaceous or Jurassic rocks, the under-scarp of their lofty cliffs is often constituted by Tertiary shaly beds of older eocene age. These strata principally consist of alternating layers of shale and sandstone, the sandstones being usually friable and greenish, the clays blackish or greenish, sometimes weathering into soft clay. Although there is a great lithological sameness about all these eocene shaly beds, yet they contain rocks belonging to two series very different in geological age. The newer series which is the one most widely spread in the region surveyed is known in the geological nomenclature of India as the Lower Khirthar. It underlies conformably the Upper Khirthar limestone and is not known to contain any minerals of value. The older series which is known as the Ghazij or Upper Laki series is only found in Sarawan, principally north of the great plateau of Upper Khirthar limestones. It underlies the Upper Khirthar limestones unconformably and the junction is often characterised by a zone of bright red and yellow clays of lateritic origin, indicating that the surface of the Ghazij beds was converted into dry land during the interval that elapsed between their deposition and that of the Upper Khirthar limestones. These lateritic beds cannot always be depended upon to distinguish the Ghazij from the Khirthar shales; for they are not always distinctly developed, and it is then only by means of the fossils occasionally found accompanying these rocks that the two series can be distinguished from one another. Nummulites belonging to the species *Nummulites atacicus* and *Assilina granulosa* characterise the older or Laki series. The species *N. lævigatus* and *N. aturicus* (*N. perforatus*) are characteristic of the newer series. The distinction of the two series is a matter of considerable importance, for it is the older one, the Ghazij, that contains all the coal of Baluchistan, the Khirthar shales being sterile.

Dry land conditions such as intervened between the deposition of the Laki and Khirthar, also occurred between the periods of

marine submergence during which the other sedimentary groups of Baluchistan were deposited. For instance, the conspicuous Lower Cretaceous limestones which I have already noticed as encircling the great anticlinal bosses of Jurassic limestones rest sometimes on Middle Jurassic beds, sometimes on older beds of Liassic age: in the latter instance, the massive limestones of the Middle Jurassic have either never been deposited, or, if they once existed, they have been redenuded away during the interval that elapsed between the Lower Jurassic and Lower Cretaceous periods. Another unconformity occurs between the Lower and Upper Cretaceous: the Middle Cretaceous is absent from Baluchistan just like the Upper Jurassic; even the lower part of the Upper Cretaceous is missing, so that all the Upper Cretaceous beds of Baluchistan are uppermost Cretaceous. The Laki beds, in their turn, are unconformable to the Upper Cretaceous, the Khirthar to the Laki, the Nari (Oligocene) to the Khirthar.

These unconformities account for the variations observed in the geological sections at different places. Not only were the beds irregularly denuded during the continental periods, but after each continental interval, the sea did not encroach simultaneously over the whole area, so that certain formations represented by thousands of feet in one section may be feebly developed or completely missing in another section at no great distance.

The most variable of all these strata are the Upper Cretaceous ones, sometimes represented mostly by limestones, sometimes mostly by sandstones, sometimes by a combination of shales, sandstones and limestones. Their thickness varies as much as their composition: in some places the whole group is absent, in other places, for instance in the Pab range, it is represented by thousands of feet of coarse sandstones.

A particularly inconstant member of this variable Upper Cretaceous group is a volcanic formation corresponding with the Deccan Trap of the Indian Peninsula. It occurs both in the shape of superficial volcanic accumulations such as basalts, agglomerates, ash-beds, interstratified with marine sediments, and as intrusive masses, representing the underground portions of the volcanoes, which have now become exposed owing to the subsequent upheaval and denudation of the area. These intrusions are all of the basic class of igneous rocks, principally dolerites and serpentines. They are largely developed in Jhalawan especially in the region surrounding

Nal, from Nal to Jebri, from Nal to Wad, and throughout a broad zone west of the Porali river. This zone crosses the Porali river just north of the plain of Las Bela, and continues as a broad belt east of that plain as far as the sea-coast at Gadani. Valuable metallic ores occur in connection with these intrusions and the extensive zone along which these igneous rocks have been observed deserves to be prospected in detail.

The newest of the great geological systems in that known as the Siwaliks, consisting of clays, sandstones, and conglomerates. As a rule they are ill-exposed in the interior of the calcareous region, being mostly concealed by alluvial deposits, as in the neighbourhood of Mastung. But considerable exposures are to be seen along its eastern margin, on the borders of the Kachhi plain. The sulphur mines of Sanni are situated in this formation.

The leading features and the distribution of the several geological formations occurring in the calcareous region are summarised in the following table :—

4.—TABULATED LIST OF THE GEOLOGICAL FORMATIONS CONSTITUTING THE EASTERN OR CALCAREOUS REGION.

Classification.	Geological formations.	Principal exposures.
Siwaliks (Upper Miocene and Lower Pliocene).	Sandstones, conglomerates, and bright coloured gypsiferous clays.	Hill-ranges bordering the Kachhi plain at the easternmost edge of the district. Also some imperfect exposures about Mastung and in the northern part of the plain of Las Bela.
Nari (Oligocene)	In the portion of Sarawan included in the calcareous region, these beds consist principally of gypsiferous clays, of sandstones, and of limestones, the latter, usually brown. In the calcareous portion of Jhalawan, they consist largely of massive sandstones resting upon a considerable thickness of massive limestones, usually pale-coloured. All these strata correspond in age with the "Kojak Shales" of the flysch region, and are crowded with the foraminifera known as *Lepidocyclina* and *Nummulites intermedius*, both of which characterise the Oligocene formation in Europe.	In Sarawan, the beds of gypsiferous clay or shale with their associated limestones and sandstones are observed along the foot hills bordering the western side of the Shirinab and Manguchar valley, and also in the Drang valley and other synclinal valleys west of the Nagau range. In Jhalawan, both the massive sandstones and massive limestones are extensively developed along the Lower Mula valley. The massive limestone forms most of the higher peaks of the Khirthar range, and also the ranges constituting the western margin of the calcareous region from the valley of the Gidar Dhor in Jhalawan up to the northern frontier of the State of Las Bela.
Khirthar (Middle Eocene) — Upper	Massive white limestones with *Nummulites aturicus* and *N. complanatus*.	Principally along the Lower Mula valley and the Khirthar range.
Khirthar (Middle Eocene) — Middle	Massive limestones with *N. lævigatus* and *Assilina spira*.	The synclinal valley of Drang in north-east Sarawan, Melabi hill, the Sarun plateau, the Harboi range, and all the hills constituting the great Eocene plateau extending across southern Sarawan and northern Jhalawan. Mishkin and other limestone ranges west of the Gidar Dhor. Syncline of the Lower Mula, Khirthar range. Bedur, Chapar and other ranges along the Lower Hab.

Age	Series	Rocks	Localities
Middle Eocene	Khirthar series, Lower	Khirthar shales, thin-bedded shales, limestones and sandstones.	Plain of Gazk, plain of Zahri, valley of the Gidar Dhor, south of Gidar and Chad, plains of Bhagwana, of Khozdar and Zidi, plains of Kharzan, of Warum, of Karu, synclinal valleys of the Upper Mula, of the Hanjira, and several of their tributaries, Gaj valley, Hab valley, etc.
		"Ghazaband limestone" black limestone with *N. irregularis*, *N. lævigatus*, *N. obesus*, *Assilina exponens*, etc.	Mulki and Palki range; first series of ranges west of the plains of Kharzan, of Warum, of Karu; and many other localities where it underlies the Lower Khirthar shales.
	Laki series	"Ghazij beds": gypsiferous clays, sandstones, and, occasionally, coal-seams and limestones with *N. atacicus* and *Assilina granulosa*.	Low hills north of the Narmuk plain. Nagau range.
Senonian (Upper Cretaceous)		Volcanic conglomerates accompanied by shales containing *Cardita Beaumonti*.	These various rocks are scattered all over the region especially in the synclinal areas between the great anticlinal ridges of Jurassic limestones. The Pab sandstones attain an enormous thickness in the range of that name which consists largely of them. The Hemipneustes beds are especially well developed in Sarawan at the Morau anticline north of Narmuk and in Jhalawan near Kharzan and south of Karu. The olive shales with ammonites are best seen south of Karu.
		"Pab Sandstones," massive, rather coarse, sometimes of enormous thickness accompanied by volcanic material.	
		Olive shales with numerous ammonites, occasionally interbedded with volcanic ashes.	
		Limestones and calcareous shales with *Hemipneustes*.	
		Of the same age as these various Senonian strata are some enormous intrusive masses consisting of dolerites, basalts and serpentines belonging to the same geological formation as the volcanic conglomerates and ash-beds above-mentioned. All these volcanic rocks are the representatives of the Deccan Trap of the Indian Peninsula.	These rocks outcrop at intervals along the broad valley extending from Rodinjo, south-west of Kelat to Gidar. They are largely developed between Gidar and Nal, all about Nal, between Nal and Jebri, and between Nal and Wad. From Wad, a broad zone situated west of the Porali river, traverses southern Jhalawan from north to south; it crosses the Porali river just north of the northern extremity of the plain of Las Bela, and continues east of that plain up to the sea-coast at Gadani.

Classification.	Geological formations.	Principal exposures.
Lower Cretaceous	"Lituola Beds": flaggy porcellanic limestones and shales, buff or pale green, containing numerous small foraminifera, principally of the genus *Lituola*. "Parh limestones": porcellanic, regularly stratified limestones, usually intensely white, except for some bright red beds mostly at the base of the formation. "Belemnite Beds": black splintery shales containing belemnites in abundance.	These formations surround the outcrops of Jurassic beds. They attain a vast thickness in the neighbourhood of Khozdar and Zidi where they build up lofty ridges without any associated exposures of underlying Jurassics.
Middle Jurassic — Callovian	"Polyphemus beds": alternations of rather thin-bedded limestones and shales, named after the gigantic ammonite species *Macrocephalites Polyphemus* which occurs in them. They correspond in age with the strata exposed in the Sembar Pass, Sibi district, and with the Chari group of the Kachhi peninsula.	The core of the Morau anticline, north of the plain of Narmuk in Sarawan.
Middle Jurassic — Bathonian and Bajocian	Massive grey limestones several thousand feet thick.	The Chehiltan range, the ranges east of the Mastung valley, the Koh-i-Maran, most of the hills bordering the Bolan district, some ranges west of Shekran, some hills near Wad.
Lias (Lower Jurassic)	Dark-grey, almost black regularly stratified limestones, several thousand feet thick, sometimes interbedded with richly fossiliferous dark calcareous shales.	In Sarawan, these beds constitute the underscarp of the Chehiltan; the ranges enclosing the Manguchar and Shirinab valley both to the east and west: the Siah range west of Kelat. In Jhalawan, the huge anticlinal Jurassic domes consist principally of liassic beds. The principal ones are the eastern spurs

		of the Mulki and Palki, the southern continuation of these ranges forming the lofty hills Belau, Hazar Meshi, Bolau, Chilak, and other unnamed masses rising in the angle between the upper and lower Mula valleys, the enormous anticlinal domes of Zardak and Sumbaji to the south-west of Karu, several massive anticlinal domes south of Zahri, the unnamed anticlinal domes south-west of Khozdar and north of Zidi, the tall massive ranges east of the Porali. These latter ranges continue in Las Bela territory east of the plain of Las Bela.
Carboniferous or Permian . . .	Limestones containing *Productus* and other carboniferous fossils.	Some hills at the southern end of the Manguchar valley, north-west of Kelat.

5.—THE FLYSCH REGION.

The flysch region includes the western border of Sarawan and Jhalawan, the western portion of Las Bela, and the whole of the Mekran district with the exception of a narrow fringe of territory bordering upon Kharan near the Mashkel river, where one observes some pliocene Siwalik sandstones, and some eocene slates. The eastern limit of the flysch region is formed by the eastern side of the Gurgina valley, the calcareous ranges extending from Nimargh to Maraf and from there to Kodak and Greshag, the calcareous ranges from Nal to Wad and to Wadinghar, and finally, the alluvial plain of Las Bela. The whole of this region is occupied by one geological formation, mostly a monotonous series of folded sandstones and shales of greenish colour known as "Kojak shales," forming innumerable close-set parallel ridges. They are mostly of oligocene age, and correspond with the "oligocene flysch" of Europe. In the neighbourhood of the Mekran coast these same beds have a somewhat different appearance because the argillaceous rocks elsewhere compressed into shales or slates have remained in the state of a friable clay, scarcely differing from the marine ooze which originally constituted them. The huge masses of white sandstones which overlie these clays, and constitute the peninsula of Ormara, the Hinglaj mountains, and other sandstone ranges in the neighbourhood of the Mekran coast, are somewhat newer than the bulk of the Kojak group, their age being Lower Miocene (Burdigalian to Helvetian).

Owing partly to the less scanty rainfall, and partly to the presence of impermeable clay beds and absence of fissured calcareous masses, the topography is much more like that produced by normal denudation, than in the limestone districts of Baluchistan: the synclines constitute the hill-ranges, the anticlines the intervening low ground, a disposition which is just the reverse of that observed in the neighbouring calcareous districts. This is especially noticeable in the neighbourhood of the Mekran coast where the grand sandstone ranges always exhibit the structure of shallow synclines, the intervening low ground being all occupied by the underlying shales of clays whose structure is anticlinal. In this neighbourhood where the softer beds have not become indurated into hard shales or slates, the lower ground occupied by the anticlines exhibits an extraordinarily complicated topography of small hills consisting of shales or clays weathering into mud, riddled by a network of innumerable

ramified ravines. The immense mural escarpments of the overlying massive white sandstones tower over the confused mass of the mud hills with a grand simplicity of outline that forms an imposing contrast. Mud volcanoes are situated along the axes of these anticlines. They will be referred to again in connection with the possible occurrence of petroleum which their presence perhaps indicates.

The contrast between the two types of denudation exhibited by the calcareous and the flysch region, is illustrated in the sections, Plates 8 and 10, accompanying this report. In the section, Pl. 8, the highest summit is part of an anticlinal dome. In the other, it is part of a shallow syncline. Both sections show the same peculiarity with respect to the anticlines which are much more pronounced than the intervening synclines, this being quite independent of whether the ridges shaped by denudation be anticlinal or synclinal.

6.—RECENT FORMATIONS.

Recent formations are not restricted particularly to either the eastern or western district. The broader valleys and plains are occupied by fine-grained alluvium which constitutes excellent soil wherever irrigation is available. The valleys of Mastung and Manguchar, of Nal, Khozdar and Zidi, of Wad, the great alluvial plains of Las Bela, Panjgur, Parom, Kech, are instances of extensive alluvial areas. The huge talus formations that usually skirt the mountain ranges of arid regions and are known in Baluchistan as "daman" are observed principally in Sarawan and in the northern Mekran. It is a formation of this kind that yields the artesian water of Quetta. But, except along the northern borders of Sarawan, this formation is not extensively developed in the region here dealt with, especially when compared with the neighbourhood of Quetta, and the more arid regions of the Zhob and of Nushki; this is largely due to the difference in the amount of rainfall. For the same reason, sand dunes are almost absent from the countries visited last season, the only noticeable occurrences being those north of Mastung, and the dunes along the sea-coast.

The raised beaches observed along the sea-coast are interesting recent or perhaps pleistocene formations.

II.—ECONOMIC CHAPTER.

Judging from its geological constitution, it is improbable that the western or flysch region contains any minerals of value, except,

perhaps, petroleum in the neighbourhood of the sea-coast. In the eastern or calcareous region, minerals are to be sought principally in the Ghazij shales and in the basic intrusions, the first being the coal-bearing series, the second being connected with the mineral veins. Barytes occurs in the Parh limestones, sulphur and alunite in the Siwaliks, while the majority of the rocks forming the calcareous region could be used for lime making.

As explained in the introduction to the Geological Summary detailed prospecting was out of the question during the past field season. It is hoped, however, that the following notes regarding various minerals may be of some use and interest.

1.—COAL.

The only place at which I actually observed coal is half way between Johan and a place called Ziarat. The section, Pl. 8, shows the situation of the coal-seam at this place, the general geological constitution being as follows:—

Formations.	Approximate thickness.
Middle Khirthar or Spintangi limestone	600 feet.
Ghazij group, consisting of friable shales, and, especially towards the base, sandstones with plant impressions. In the upper part of the group, one observes a coal-seam some 3 or 4 feet thick. Bright coloured lateritic clays occur at the junction with the unconformably overlying Khirthar	2,000 „
Parh limestones	1,000 „
Belemnite shales	200 „
Massive limestone (Middle Jurassic)	2,500 „
Lias	2,500 „

Owing to the extremely friable nature of the clay beds amongst which the coal lies, it is so hidden by débris that it is not possible to obtain an accurate estimate of its thickness. I succeeded in actually seeing it only at one place which was very difficult of access on account of the steepness of the friable and insecure slope leading to it. The coal exposed at that place is in a very splintery

condition. Its quality is very poor, but I could not get a representative sample without uncovering the outcrop which would have caused undesirable delay. It is principally along the northern escarpments of the great eocene plateau from Gishk hill to Melabi hill, that a search should be made for coal seams. Throughout the eastern escarpments of the great plateau, the shales underlying the Middle Khirthar limestone no longer belong to the Ghazij group, but to the less ancient Lower Khirthar which is not coal-bearing. The whole of the area occupied by the Ghazij outcrop is worth prospecting. The impure coal of Avagul near Mastung perhaps belong to the Ghazij series. It was examined by Mr. Tipper whose notes are appended to this report.

In the list of marches furnished to me by Major Showers, mention was made of traces of coal at Shirinab west of Mastung. Unfortunately, I forgot this mention when travelling to Shirinab. The correctness of the information is shown by the occurrence of Ghazij shales along the western side of the Shirinab valley. But the extremely disturbed condition of the strata along this outcrop does not favour the notion of easily working it. Not only are the strata along this outcrop greatly crushed and compressed, but, as is shown in the section, Pl. 9, they are almost vertical, which greatly reduces the amount of available mineral. It is possible that the continuation of the same beds exists in a less disturbed condition beneath the Shirinab valley, but this could only be tested by boring.

2.—PETROLEUM.

The rocks of the calcareous region do not appear suitable for the underground storage of petroleum, on account of their extremely fissured condition. The attempts hitherto made either to exploit petroleum springs or prospect for that mineral have mostly been carried out in places resembling the calcareous region dealt with in the present report, and this may account for the small measure of success hitherto attained. In the area here dealt with, there are two regions where the prospect seems somewhat more favourable: Las Bela and Southern Mekran, where the rocks belong to the Kojak or Mekran system, and Kachhi, where they belong to the Siwaliks.

(*a*) Possible oil-field of Las Bela and the Southern Mekran.

As already explained, the rocks of the Mekran district consist of alternating shales and sandstones disposed in parallel folds closely packed in the interior of the country, but broad and shallow in the neighbourhood of the sea-coast. In the interior of the country, the rocks are greatly crushed and disturbed, while they are very little altered near the coast. In this coastal region, the series consists of a mass of white or pale buff sandstones amounting in places to several thousand feet in thickness, known as the Hinglaj sandstones which are underlaid by pale-greenish shales or clays. There is a considerable thickness of these shales underlaid in their turn by alternations of shale and sandstone. The clays or shales are exposed in long narrow anticlines whose axes run parallel with the sea-coast. In section, these anticlines have a very steep roof shape along their axes, the dip of the strata becoming gradually shallower away from them. In the intervals between the anticlines, the Hinglaj sandstones occupy the broad and shallow synclinal areas, constituting the Hálá and Hinglaj ranges, the Dhrun, the Gurang, the Talar, the rocky promontories of Ormara, Gwadar and Junri. The structure is illustrated in the section, Pl. 10. Such a structure is one ideally suited for the underground accumulation of mineral oil. Petroleum, when present, always accumulates along the axes of anticlines, and, in the present instance, the steepness and continuity of the anticlinal axes, and the imperviousness of the covering clays are highly favourable features. Although no actual flow of liquid oil has been observed at any place yet there are some reasons for believing that these strata are oil bearing.

Foremost amongst these indications is the occurrence of the mud volcanoes, precisely along these anticlinal axes; it is uncertain, however, whether the gases emitted contain gaseous hydrocarbons, such as would indicate the presence of liquid petroleum. It is conceivable that the anticlinal arches may be impermeable enough to arrest the upward passage of the stored liquid, and yet that minute fissures or pores might suffice to afford a passage to the gases. The water which accompanies the gases does not rise from the depths of the anticlinal arches. It is merely stored in the overlying strata and is forced upwards by the gas rising from below; its similarity

of composition with the neighbouring sea-water, and its temperature identical with that of the sea and air indicate that it originates from a small depth. Therefore the absence of liquid hydrocarbons from the products of the mud volcanoes is no indication that they do not exist underground, and all the other circumstances seem favourable enough to justify experimenting in order to ascertain their presence or accessibility.

The best chances of success will be obtained if the site for the experimental boring is selected at a place where the anticlinal roof has been considerably denuded in order to traverse as small a thickness as possible of the impermeable clay. This thickness is, in any case, an uncertain factor, because the exposures do not afford any means of readily ascertaining the thickness of clay or shale that will have to be traversed; but, of course, it will be least where a considerable portion has already been removed by natural agencies. Another uncertain factor is also introduced by the singular shape of the anticlines which have a very steep dip in the immediate neighbourhood of their axes. It is evident that if the site chosen is not on the actual axis of the anticline, the high dip of the beds will considerably increase the depth to which it will have to be carried before meeting the underlying layers. At the actual axis of the anticline the bedding is of course horizontal, but the stratification of these clay masses is so obscure that it is not possible to determine its exact position: consequently if the first boring could not be carried through the entire thickness of the clays, and therefore yielded no oil, it would still be necessary to sink new ones a little to the north and south of the line along which the first experiment was made, and the trials should be continued until one of these borings struck a sandstone bed. It is to be noticed that while this peculiarity of structure is unfavourable for prospecting, it is eminently well suited to storage. The left bank of the Hingol, north-east of the word "Aghor" on the ¼″ map, would be a suitable place for the first trial. The success or failure of the initial experiments will indicate whether it is worth while investigating the other anticlines shown on the map. The borings must be started with a wide diameter, so as to be able to reach a considerable depth, between 1,000 and 2,000 feet if necessary. Moreover, the wider the boring, the more remunerative would it be in case it struck oil; and the importance of the possible result is sufficient to justify a fairly large outlay.

Further west, in Persia, mineral oil is remuneratively extracted from these same beds. In geological age, they correspond with the oil-bearing strata of Burma, and with the "Schlier" of Europe, that is with one of the most constantly petroliferous geological formations.

(*b*) Possible oil-field of Kachhi.

Petroleum springs have been reported as occurring amongst the Siwalik strata surrounding the Kachhi plain. The districts of Sarawan and Bolan, the Mari and Bugti country, are fringed by a zone of Siwalik hills bordering the Kachhi plain. In these hills, the Siwalik system consists of alternating sandstones and clays whose composition and frequently anticlinal structure seem quite favourable to the storage of petroleum. They are, therefore, worth prospecting at suitable places. Sulphur, salt and gypsum, the usual associates of mineral oil, are also found in these rocks. It should be mentioned, however, that in Burma, the Siwalik system, although it seems favourably constituted for the storage of petroleum, is always sterile, all the oil being contained in the underlying beds which correspond with the beds underlying the Siwaliks of Baluchistan, that is with the Mekran or Kojak system.

3.—SULPHUR, SALT, ALUNITE, GYPSUM.

Salt, sulphur and gypsum (sulphate of lime) are commonly met with in petroliferous regions. Sulphur is found both in the Mekran or Kojak series, and in the Siwaliks. In both series it has been deposited from sulphurous springs. I visited some deposits of sulphur in the Mekran series at Kan Berar in the State of Las Bela. The amount of mineral which they contain is too small to be profitably extracted. The mines of Sanni in the Siwalik area bordering the plain of Kachhi appear to be much richer.

(*a*) Sulphur and salt of Kan Berar.

West of the southern portion of the alluvial plain of the Porali, separating that alluvial expanse from the Pohr valley, rises an anticlinal ridge of Hinglaj sandstones striking a few degrees west of south and ending southward by an anticlinal apse about 3 miles distant from the sea-coast close to the mouth of the Pohr. The

anticline has not been sufficiently denuded to expose the clay beds underlying the Hinglaj sandstones, except in its southernmost portion where some narrow outcrops of the typical shales appear along the crest of the anticline which is somewhat more denuded than further north. A large mud volcano rises above these clays. The sulphur of Kan Berar occurs at the crest of the anticline quite close to its southern termination. The crest of the anticline at that place is considerably denuded, yet not sufficiently to expose the typical Mekran shales that underlie the Hinglaj sandstones. The lowest beds exposed are alternating shales and sandstones belonging to a somewhat higher horizon than the typical Mekran shales. Amongst the ravines cutting through these beds, are some intensely sulphurous salt springs. The cliffs overlooking these springs exhibit veins of sulphur and salt evidently representing the channels through which the mineral waters reached the surface at a time when the ravines had not been excavated to their present depth. Both the salt and sulphur are pure and well crystallised, but the amount is too small to be of economic value.

(*b*) Sulphur and alunite in the Siwaliks.

Of the sulphur mines situated in the Siwalik area, the best known are those of Sanni which have been profitably worked for many years. In addition to sulphur, these mines yield alunite (sulphate of alumina). The mines have been visited by Mr. Tipper whose notes on the subject are appended to this report.

(*c*) Gypsum.

The tertiary clays and shales of all ages, whenever they are but slightly disturbed, contain numerous crystals of gypsum scattered through their mass. In regions where these same beds have been converted into hard shales, the gypsum disappears, giving place to veins of calcite. Lastly, when the degree of alteration of the beds is carried still further, so that they become slates, the calcite veins are replaced by veins of quartz. The gypsum observed in the region visited last season could be locally used for manufacturing plaster-of-Paris, but I have not come across any continuous masses of the mineral, such as might be worth exploiting on a large scale.

4.—MINERALS CONNECTED WITH THE IGNEOUS INTRUSIONS.

(*a*) Copper and lead.

The ores of copper and lead for which Jhalawan has long been known are mostly, if not entirely, connected with the great basic intrusions described in the Geological Summary. Being unaware of the situation of the intrusive zone before commencing our tour, it was not possible either for Mr. Tipper or myself to do any prospecting. Now that a map exists showing the position of the zone, it will be possible to investigate it in detail. The situation of the zone has been described in the Geological Summary and is indicated on the accompanying map.

I have observed one instance where a copper deposit appears to occur in the eocene coal-measures, in beds newer therefore than the great intrusions. This is between Ziarat and Johan, in Sarawan, at the same locality where I saw the coal-seam above described. The locality was indicated to me by Duffedar Sarang Khan. The hill-slopes at this place are so friable and the ground so much broken up, that I was unable to find the actual ore-body, probably a vein, but the hill-slopes were strewn with its weathered products, in the shape of concretions of malachite and azurite (carbonates of copper). I did not succeed in obtaining any of the unweathered ore, but some of Sarang Khan's specimens contain, beneath the crust of carbonates, a core of copper-glance, one of the richest ores of copper. This ore deposit is worth closer examination than I was able to give it. From its position amidst eocene strata it appears to be much newer than the basic intrusions. Perhaps it represents a product of solfataric phenomena that may have lingered beyond the era of the great volcanic eruptions. In other parts of Baluchistan I have come across igneous intrusions cutting through eocene strata, and representing a period of igneous activity (not necessarily volcanic), newer than the Deccan Trap, and whose age is oligocene or lower miocene. This is perhaps the case with the vein near Johan, and, if so, it would constitute an exception to the usual age of the metallic deposits of this district.

Formerly lead and other minerals were obtained from the mines of Shekran near Khozdar, apparently connected with the typical basic intrusions of cretaceous age. The mines were visited by Mr. Tipper, whose notes are appended to this report.

(*b*) Magnesite.

Some 7 or 8 miles south of Wad, north of a camping ground known as Bania Pani, the serpentine intrusions are crowded with veins of a white mineral which I took to be magnesite. The network of veins is sometimes so dense that the hill-slopes appear entirely white. The specimens have got mislaid on their way to Calcutta. If they can be recovered, they will be examined in the laboratory, and a note added to this report. Magnesite thus situated and in such abundance might be worth extracting in the event of a railway extension to Las Bela.[1]

(*c*) Serpentine.

The serpentines so largely developed along the intrusive zone constitute sometimes handsome ornamental stones. Some varieties are wrought into small ornaments at the pilgrimage place of Shah Billawal.

5.—IRON PYRITES AND BARYTES.

Large concretions of marcasite (a form of iron pyrites) are commonly found in the lateritic layers at the junction of the Belemnite shales with the underlying Jurassic, but not in sufficient amount at any one locality to be remuneratively extracted.

Barytes has been observed in the Belemnite shales by Mr. Tipper whose notes are appended to this report.

6.—IRRIGATION.

The area dealt with in this report includes most of the less arid portions of Baluchistan, this being especially the case with the Mekran district. My observations were too hurried to enable me to make suggestions regarding any extensive scheme of irrigation, but I have seen enough to feel convinced of the desirability of making some provision to save the enormous amount of water that yearly runs to waste. Apart from the possibility of storing a vast amount of water from occasional showers, a great deal could be done to turn to better account, than it is at present, the considerable per-

1 Since our visit to Las Bela, manganese-ores have been discovered in this State. Precise details are not yet available. The ore is psilomelane.

ennial flow of the large Mekran rivers. The artificial dams and terraced fields known as "gorband" whose presence in the Nushki-Chagai district appears to indicate a recent dessication of that tract, are extremely numerous throughout Jhalawan, Sarawan and the Mekran. In a great many cases these structures have been erected as dams across considerable streams, but have now fallen in disrepair, and have been largely carried away by floods. The climate has probably not deteriorated so much as that of the districts further north. The gradual dwindling of the lakes occupying areas of closed drainage which must have acted so powerfully in causing the dessication of the desert further north, has not affected to the same extent the areas here reported upon, for their drainage is, for the greater part, connected with the ocean, and even the portion of the Mekran tributary to a closed-drainage area, feeds a river of considerable size, the Mashkhel.

In the calcareous districts of Baluchistan, the narrow gorges interspersed along the course of the rivers seem favourable to the building of dams that would allow the formation of artificial reservoirs. The fissured condition of the calcareous masses might interfere with the water-tight character of the reservoirs to an extent that cannot be predicted, as no important work of the kind has yet been erected in Baluchistan.

There are no fissured limestones in the western region, where perennial rivers such as the Hingol, the Mashkhel, the Dasht and some of their tributaries could be turned to account for irrigation to a far greater extent than they are at present, by constructing dams at suitable places. All along the course of the Lower Hingol, south of latitude 26°, there are large areas of absolutely barren soil on either bank, the reason being that the river is encased between shale banks some 30 feet high which it never overflows even when in flood. By constructing dams and canals to distribute water over such areas, these plains could be cultivated. At Hingol itself, where the river finally emerges from the hills, the same thing could be done to irrigate the plain extending up to the sea-coast. The construction of a series of such works along the river would also tend to check the disastrous floods to which it is subject.

Still more than in the case of the Hingol, works of a similar nature are desirable in connection with the Dasht river and its tributaries, on account of the vastness of the alluvial plains which it traverses, the excellence of their alluvial soil, and the large

volume of water carried by the river. I have not visited the river gorges north of the Sami and Mand plains, respectively east and west of Kej, but judging from the map, they appear well adapted to the creation of artificial reservoirs that would still further enhance the fertility of the Kej plain. Another work at the gorge north of the Dasht plain would confer similar advantages to that fertile expanse of splendid soil, while a canal could be constructed to bring a plentiful supply of drinking water to the well situated harbour of Junri. Along the tall ranges north of the Kej valley, many minor works could be constructed to economise something of the large amount of water that runs to waste after every shower of rain.

It should be possible to treat the Mashkhel in the same way, but this would benefit mostly territory belonging to Kharan.

Of course such works would require a large outlay. But the potentiality of the Mekran seems to me so incomparably superior to that of any other part of Baluchistan that the matter deserves careful consideration. The climate is suited to all kinds of crops: wheat, cotton, indigo, sugar-cane, rice, etc. The population appears intelligent and industrious. If the natural water-supply of the region could be made available to its fullest efficiency, the province could support three or four times its present population, and would become a prosperous annex of the fertile portions of Sind.

With regard to the chances of artesian wells, it is to be noticed that the geological formation that yields the artesian water of Baluchistan is not greatly developed in the region which I visited during my last tour. This is the recent talus or "daman" described in the Geological Summary. Owing to the less arid conditions of the region, combined frequently with a smaller relative altitude of the hills, this formation does not attain anything like the proportions which it has round Quetta, or in the Zhob or Chagai districts. When developed at all conspicuously, it usually spreads out at a very shallow angle, so that a high pressure in the underground reservoir cannot be expected. At the foot of the northern slopes of Melabi hill, at the south-east corner of the southern Zahri plain, the western border of the Kachhi plain, in the plains of Jhau and of Kej, the talus seems sufficiently developed to indicate the possibility of artesian conditions, but in all these places drinking water is to be had in abundance and an artesian well would not be of great utility.

APPENDIX.

Notes on some minerals.

By G. H. Tipper, *Assistant Superintendent, Geological Survey of India.*

Barytes.—This mineral is found widely distributed through Kalat and Las Bela States in the Belemnite shales of Lower Cretaceous age. It has also been found in the middle Khirthar shales. The two chief localities are the lower scarps of the Pab range near Pabni chauki and the Sarmowli river between Chad and Anjira. Wherever found the mineral occurs as scattered concretions in association with nodules of pyrites. Of the two localities the Sarmowli river is too remote from any centre: while that near Pabni is very favourably situated, as it is only about two days' march from Karachi. Barytes has a considerable commercial value in Calcutta, but I am not in a position to say whether there is any market in Karachi. From the mode of occurrence of the mineral it is impossible to estimate the quantity available, but considering the great outcrop of the Belemnite shales in the vicinity there must be a fair amount of the mineral scattered about.

Sulphur.—Sulphur occurs at the Bhitari river near Sanni, at Gokurth and Draj Bent in the Bolan Pass. In the Bolan the outcrops are much obscured by sinter deposits. It is of interest as the rock in which the sulphur occurs is a massive limestone of Upper Cretaceous (Cardita Beaumonti) age. At Sanni the sulphur has been at one time extensively mined. I was told that this was done on behalf of the Amir of Afghanistan and that mining was stopped at the British occupation. Since then the openings have all been stopped by débris and in addition the mine has at some time been set on fire. I had the mine cleared, but the opening proved too small to allow me to get down any distance. Some of the escort managed to scramble in for some way and got good specimens for me. The sulphur occurs as veins and impregnations in the clays of the Siwaliks. Some of the clay-bands are so full of sulphur that they burn with ease. Small quantities are even now extracted for the local manufacture of gunpowder.

Alunogen or *Sulphate of Alumina* occurs in veins associated with the sulphur. It is almost pure and was at one time used as a mordant. Both the sulphur and the alunogen have been deposited from sulphurous springs.

Petroleum shows are to be seen both near Sanni and in the Bolan. They do not, I think, indicate that there are reservoirs of oil waiting to be tapped, but they rather point out places where the oil has been and from which it has escaped. The experiment of boring for oil was tried without success at Kirtha in the Bolan. At the sulphur mines of Sanni I was informed that the purification of the sulphur was carried out by means of the earth-oil found in the mines. From the description given me it must be like that of the Bolan, a thick tarry maltha, and it seems doubtful whether there is any reservoir of oil.

Lead and *Antimony.*—According to all the inhabitants of Jhalawan both lead and antimony are found at numerous localities in the province. This is probably quite true, but the only place where these metals are

known to occur is at Shekran, about 14 miles north of Khozdar. This locality was visited by Dr. Cook about 60 years ago, at which time no work was being done. Previous to this they had been seen by Masson in 1843. He gives a description of the method of smelting, which resembled that of the open hearth process. At the present time small pieces of native (?) lead washed down by the streams provide the Brahui with the necessary lead for bullets. The mines occur in the hard blue limestones of the Lias and in the rather softer beds of the middle Jurassic. They are extremely numerous and many of them are now blocked by débris, so that it is impossible to say whether they are merely surface diggings or not. The old method of working seems to have been very simple. The ore was extracted, sorted at the mouth of the pit and the selected ore was taken to a spot near the stream to be smelted. At this spot there is a large heap of slag now partly over-grown with "pish."[1] When the mines were in full swing there must have been a much larger supply of fuel in the vicinity than there is at present. The chief ore is cerussite or carbonate of lead. So far no ores of antimony have been found, but analysis of the slags shows antimony present in every case, so that antimony ores are almost certainly there. Amongst other specimens some manganese-ore was picked up, but it is entirely superficial in origin. None of the slags contain any traces of silver, so that it is doubtful whether silver-lead ore does occur. Supposing that a fairly rich metalliferous vein were discovered in this locality, it would be impossible to smelt it on the spot, on account of lack of fuel at any convenient distance. It would, I think, never pay to carry crude ore the present great distance to the railway.

Coal.—At Avagul, south-east of Mastung, there is some carbonaceous shale. It occurs in shaly limestones of Lower Eocene age. It is of no value as fuel.

Copper.—Beyond occasional traces of copper, no true vein of copper ore was discovered, although search was made on every possible occasion.

EXPLANATION OF PLATES.

PLATE 8.

Section showing position of coal-seam at Ziarat, west of Johan.

PLATE 9.

Section showing position of "Laki" strata in the Shirinab valley.

PLATE 10.

Section illustrating the geological structure near the Mekran coast.

PLATE 11.

Diagram illustrating the position of anticlinal axes in Eastern Baluchistan and Western Sind.

PLATE 12.

Geological map of Eastern Baluchistan and Western Sind.

[1] *Nannorhops Ritchieana*, Wdl.-*Chamærops Ritchieana*, Griff.

NOTE ON A HIPPURITE-BEARING LIMESTONE IN SEISTAN AND ON THE GEOLOGY OF THE ADJOINING REGION.

BY ERNEST W. VREDENBURG, A.R.S.M., A.R.C.S., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 13 to 16.)

INTRODUCTION.

Amongst a geological collection from Seistan, forwarded to the Geological Survey of India by Mr. T. R. J. Ward and Sir Henry McMahon in 1905, there are a few fossils which are of special interest as they include specimens of *Hippurites.* The locality is situated nearer to the frontiers of the Indian Empire than any other in which specimens of the genus have been discovered. Up to the present there is no instance on record of a true hippurite having been found in India.

OUTLINE OF THE GEOLOGY OF SEISTAN.

By piecing together the information gathered by Huntington (*The Basin of Eastern Persia and Seistan, Carnegie Institution,* 1905), McMahon (*Recent Survey and Exploration in Seistan, Geog. Journ.,* 1906), and the surveys previously accomplished by me (*Geological Sketch of the Baluchistan Desert and part of Eastern Persia, Mem. Geol. Surv. Ind.,* Vol. XXXI, 1901), it is now possible to form a fairly connected idea of the Geology of Seistan.

Seistan the lowest lying portion of a vast depression.

The populated districts of Seistan are distributed through the lowest lying portions of one of those depressed almost flat areas of closed drainage, intervening between mountain ranges, such as characterise many parts of Persia and Central Asia. In this particular case, the depression occupies a considerable portion of Southern Afghanistan, stretch-

ing from east to west for a distance of some 320 miles, the breadth from north to south being about 180 miles. The lowest lying portion is along the western margin of the depression. The greater part of this area is a desert, except along the banks of the Helmand river, and in the more deeply depressed western portion where numerous artificial canals supply water for irrigation from the distributaries of the Helmand. This river spreads in delta fashion over the lowest lying part of the tract, some portions of which are flooded by shallow sheets of water whose extent varies according to the season of the year. In addition to the Helmand, several rivers, of which the most important are the Khash Rud, the Farah Rud and Harut Rud, enter the depression of Seistan proper along its north-eastern or northern margin and contribute to supply water and silt to the area occupied by the shallow lakes.

Helmand river and delta.

The shallow lakes of Seistan proper contain fresh water. The soluble salts washed into them from a considerable drainage area do not accumulate, because the lakes are flushed during exceptional floods, the surplus water overflowing into a still deeper depression, the Zirreh Lake, situated south of the populous portion of the province. The water of the Zirreh Lake is saturated with salt.

Fresh-water lake of Seistan proper.

The Zirreh Lake.

From a geological point of view, the constitution of Seistan is the same as that of the adjacent depressions of Persia and Baluchistan, some of which have already been surveyed and described with some detail. The encircling hill ranges contain a varied sequence of highly disturbed rocks amongst which cretaceous and eocene strata especially predominate, while the depressed area is occupied by undisturbed or slightly disturbed formations belonging to three successive formations: the Siwaliks (or "Gobi formation") mostly of pliocene age, the pleistocene alluvial gravels and clays, and recent accumulations. These three groups of deposits represent three successive stages in the desiccation of the vast inland seas that were cut off from

Geological constitution of Seistan.

Encircling hill ranges.

Desiccation of the depressed areas.

the ocean in later Tertiary times by the orogenic upheavals that occurred during that period. Only, while the recent formations and even the pleistocene accumulations show no distinct signs of having been disturbed since they were deposited, the Siwaliks have been distinctly affected by movements of the earth's crust.

Disturbance of Siwaliks.

Over the almost horizontal spreads that constitute the greater portion of the depressions, these movements do not amount to anything more than a more or less local warping; but, all along the margins of the depressions, where the Siwalik beds border the mountainous ranges, these same deposits are violently upturned, being tilted at high angles, and affected by overthrusts indicating in all cases a direction of movement from the mountainous towards the low-lying region. The warping and tilting of the Siwaliks and the concomitant overthrusts must date back to the pliocene, and accounts for the manner in which these beds which, originally must have been deposited with a near approach to uniformity and horizontality over the floor of the inland seas, are now observed at varying altitudes. The inequalities in the floor of the depressed areas left dry by the desiccation of the inland seas are to be attributed largely to this pliocene disturbance. It is very likely however that a closer study than has been hitherto practicable, would reveal a certain amount of disturbance amongst the pleistocene accumulations, such as has been distinctly shown to have taken place in many parts of India, both in the peninsular and extra-peninsular regions; normal faulting seems to have affected the margins of the depressions in post-pleistocene times. Numerous volcanic cones bear testimony to a disturbance of this nature, as also the earthquakes that affect definite lines along the margins of the depressed areas. Sir Henry McMahon has drawn attention to a line of disturbance of this nature from Chaman to Nushki along the eastern margin of the great depression of Southern Afghanistan. Along the margins of the low-lying western portion, volcanic manifestations are numerous, and include the Koh-i-Sultan, Damodim, Koh-i-Dalil, Mit Koh, and another unnamed cone, all of which are situated south of the Zirreh Lake, and have already been described in these publications (*Mem. Geol. Surv. Ind.*, Vol. XXXI, pp. 274—283, 1901), while in

Siwaliks upturned along the margins of the depressions.

Pleistocene faulting and volcanic manifestations.

Seistan proper, the Koh-i-Khwaja[1] and Koh-i-Chako are of a similar nature.

Cliffs of Siwalik strata encircling the depression.

These crust disturbances account quite sufficiently for a feature that has puzzled many observers in Seistan: the depression occupied by the delta of the Helmand and the shallow lakes of Seistan and the Zirreh Lake is surrounded by cliffs of horizontal (or nearly horizontal) Siwalik strata whose shapes are evidently determined by ordinary erosion. As these cliffs surround an area which is the lowest lying portion of an inland basin, it seems difficult to account for the disposal of the material removed by denudation if one supposes these cliffs to consist of undisturbed material. The supposed absence of disturbance is, however, only a deceptive appearance caused by the horizontality of the deposits away from the margins of the plains. That the horizontality is neither general nor absolute, even in such situations, is distinctly shown by some of the photographs communicated by Mr. Ward, and also by Huntington's diagrammatic section through the Koh-i-Khwaja (*Basin of Eastern Persia and Seistan*, fig. 168, p. 286, 1905), while the highly disturbed condition of these same beds along the actual margin of the depression is evidenced clearly enough in a photograph which I have reproduced in a previous publication of this department, and which represents an exposure of this formation situated some 20 miles west-south-west of the western termination of the Zirreh Lake (*Mem. Geol. Surv. Ind.*, Vol. XXXI, Pl. 12). As there have been, therefore, considerable crust movements, it is quite to be expected that beneath certain parts of the lowest lying area the Siwaliks lie buried under a considerable depth of pleistocene and recent accumulations representing the material derived from the erosion rendered evident by the features of the cliffs above alluded to.

[1] The volcanic rocks from the Koh-i-Khwaja include:

1. Porphyritic dolerite with phenocrysts of labradorite and augite in a base of smaller crystals of the same two minerals plus iron-ore; there is some secondary serpentine. (G = 2·72.)
2. Very fine grained basalt consisting of minute crystals of felspar, augite, and iron-ore dust, with a few small porphritic crystals of augite. (G = 2·81 to 2·90.)
3. Very porous andesite of a dull brick-red colour, almost a pumice; the minute vesicles contain opal and zeolite, while some larger cavities contain calcite.
4. Ash-beds.

These rocks recall somewhat those of another small volcanic outburst occurring in the southern part of the Seistan depression, and already mentioned in a previous publication. (*Mem. G. S. I.*, Vol. XXXI, p. 283, 1901.)

Eolian denudation.

Seistan is noted for the violence of the wind that sweeps across the country for months at a time. Huntington, McMahon and many other observers have drawn attention to the extraordinary amount of eolian denudation which it produces especially amongst the soft recent deposits. Though this might be sufficient to counterbalance to a great extent the accretion of the sediment due to the silt brought down by the Helmand, it would not suffice for the local formation of the depression which there is every reason to ascribe to tectonic influences.

Confusion between Siwaliks and sub recent formations.

One of the reasons that have somewhat obscured the obviousness of this simple explanation is the failure, on the part of many observers, to recognise that a considerable portion of the deposits occupying the plains of Baluchistan, Persia, and Central Asia are identical with the Siwaliks. Instead of their being interpreted as lake or inland-sea deposits of Tertiary age, they have often been regarded as an ordinary alluvial formation of much later date. These rocks were unhesitatingly referred to the Tertiary era by Griesbach when he first observed them in the plain of Pishin near Quetta (*Mem. Geol. Surv. Ind.*, Vol. XVIII, p. 18, 1881, *Rec. Geol. Surv. Ind.*, Vol. XVIII, p. 58, 1884). Partly through an accidental misapplication of the term "Gaj" (a name belonging to a series older than the Siwaliks, but misapplied by Griesbach in consequence of a misapprehension as to its meaning), Griesbach's interpretation did not gain credit with his successors who referred the deposits in question to a sub-recent age and denied their lacustrine origin (*Rec. Geol. Surv. Ind.*, Vol. XXV, p. 36, "Manual," 2nd ed., p. 417).

The researches of the last few years have fully established the correctness of Griesbach's views, and the identity of these beds with the Siwalik formation of India and the Gobi formation of Central Asia.

Character of the Siwalik strata.

The Siwalik strata, whether comparatively undisturbed or else violently tilted, consist principally of alternating pink and greenish clays and occasionally sandstones and conglomerates. This at least is the character of the bulk of the formation, constituting the middle sub-division. Greenish-grey sandstones predominate in the Lower Siwaliks, while in the Upper

Siwaliks there is often a considerable admixture of coarse fluviatile conglomerates and of buff-coloured clays recalling the pleistocene formations.

A number of detailed measured sections, consisting principally of the alternating pink and green clays, observed along the north-western border of the depression of Seistan proper, have been represented by Huntington on Plate 5 of his work on the basin of Eastern Persia and Seistan.

Pleistocene formation.

The pleistocene formations consist largely of alternations of buff-coloured, more or less sandy clays and conglomerates. Instead of exhibiting the characters of sediments deposited under water, they recall ordinary alluvial deposits, indicating that the inland seas of the Siwalik period were then to a considerable extent dried up. Yet judging from the terraced disposition of these pleistocene deposits, a portion of the basins must have been still occupied by water, and the pleistocene deposits only became largely eroded when the water level finally sank in post-pleistocene times.

The loess.

The pleistocene formations consist largely of great accumulations of unstratified buff-coloured clay exhibiting the character of the "loess."

"Dasht" plains strewn with black pebbles.

The arid plains strewn with black pebbles that constitute the plains known as "dasht" owe their origin to the pleistocene conglomerates: the pebbles are laid bare by the wind, which removes all traces of the silt that once enclosed them, they become coated with a thin film of hydrated oxides of manganese or iron as is usually the case in desert countries.

Recent deposits.

The recent accumulations of the Helmand delta consist of ordinary river silt. In order to give a clear idea of the physical and geological relations of Seistan and of the adjacent lands, the small diagram, Pl. 13, shows the main features of the geology of Baluchistan and Southern Afghanistan so far as known at present.

FOSSILIFEROUS CRETACEOUS LIMESTONES.

The only fossils gathered *in situ* amongst the specimens forwarded by Sir Henry McMahon are those mentioned in the introduction to this note. They were collected amongst the hills

forming the north-western margin of the Seistan swamps. These hills constitute the most south-easterly spurs of one of the mountain ridges which, from the neighbourhood of Birjand, in eastern Persia, extend, with a south-easterly strike, towards the borders of the Seistan depression. The ridges gradually decrease in altitude on approaching the depression, and terminate in isolated spurs entirely surrounded by the Upper Tertiary ("Siwalik" or "Gobi") and sub-recent formations that fill the Seistan depression. Two such isolated masses constituting the terminations of one of these ridges, and along the summits of which has been carried the frontier line between Persia and Afghanistan, have yielded the fossils in question. The more north-westerly and the larger of these two islands of older rocks is known as Koh-i-Nahrahu or Koh-i-Siah, and rises to an altitude of 4,984 feet, some 3,430 feet therefore above the level of the swamps. The smaller, and south-easterly one, known as Koh-i-Maku, rises to a height of 3,900 feet.

Judging from Mr. Ward's photographs and the notes supplied by Sir Henry McMahon, the rocks constituting these hills dip at high angles, the stratification being contorted.

All the ranges running close to the Perso-Afghan frontier from the neighbourhood of Meshed to Birjand are disposed along this same south-easterly direction of strike. On reaching the longitude of Seistan their direction veers round and becomes more easterly; in the case of the ridge terminating in the Koh-i-Nahrahu and Maku, this change of direction cannot be observed, because the older rocks constituting these ridges sink beneath the horizontally bedded late Tertiary and Quaternary beds of the depression. North-east of the depression, the eastward-striking portion of several ranges belonging to the same system was crossed by Mr. Griesbach during the march of the Russo-Afghan Boundary Commission in 1883.

They are described by Mr. Griesbach as consisting of hippuritic limestones invaded by various intrusive igneous rocks (*Rec. Geol. Surv. Ind.*, Vol. XVIII, p. 60, 1884).

Koh-i-Nahrahu and Maku also consist of a hard grey limestone which yields well-preserved specimens of two species of *Hippurites.* There are also some specimens of rock showing a brecciated structure, with fragments of a green porcellanic-looking limestone embedded in a grey calcareous matrix. The green fragments resemble some of the rocks known in Baluchistan as "Parh limestones"

whose age is Neocomian. In the present instance, however, the available material is insufficient to decide whether these Neocomian rocks are represented.

The fossils include a hippurite which I have regarded as identical with *Hippurites gosaviensis* Douvillé, an undescribed *Pironæa* which I propose to name *Pironæa persica*, sections of a *Plagioptychus*, a large ribbed *Pecten*, a large very singular lamellibranch which I have been unable to identify, and is perhaps related to the *Pinnidæ* (Pl. 16, fig. 2), casts of a large, very elongate *Nerinea* (Pl. 16, fig. 1*a*, 1*b*), and of a large naticoid shell.

Hippurites gosaviensis seems to characterise, in Europe, the Upper Turonian or the beds at the limit of the Upper Turonian and Lower Senonian. The species of *Pironæa* so far described are regarded as Upper Senonian, but the present one exhibits more primitive features than its congeners, and its presence is not therefore out of keeping with the attribution of a Lower Senonian or uppermost Turonian age to these rocks.

DESCRIPTIONS OF THE HIPPURITES.

The two species of hippurites may be briefly described as follows:

Hippurites gosaviensis Douvillé.

PL. 14, figs. 1, 2.

1866.—*H. cornuvaccinum* Zittel, Die Bivalven der Gosaugebilde (Denkschr. der Kais. Akad. der Wissensch., Vol. XXV, p. 135, Pl. XXI, figs. 1—7).

1890.—*H. gosaviensis* Douvillé, Etudes ser les Rudistes (Mem. Soc. Geol. Fr., No. 6, p. 24).

1895.—*id.*, *loc. cit.* (Pl. XXIX, figs. 1—6, Pl. XXXIII, fig. 5).

There are unfortunately no specimens of the upper valve. The lower valve in young specimens up to a diameter of about 8 centimetres is conical, and more or less curved or deflected in various directions. Full-grown specimens become cylindrical, and some of the fragments are as much as 25 centimetres long, for a diameter of 8 or 8·5 centimetres. The greatest diameter observed amongst any of the specimens is 10·5 centimetres.

Externally the outer layer is ornamented with close-set angular ribs, delicately striated transversely, the intervening furrows being

also angular; their average width from furrow to furrow is about 3 millimetres. The position of the two pillars is indicated externally by grooves slightly deeper than the other furrows; the groove corresponding to the cardinal ridge is somewhat more pronounced and distinguished by the obliquity of the transverse striation disposed in "herring-bone" fashion as is usual in hippurites.

When the outermost layer of the envelope is broken off, the inner layers appear ornamented with ribs that are much less prominent than those of the outer layer, while the furrows coinciding with the pillars and cardinal ridge are much more pronounced than when the external surface is intact.

The internal disposition of the internal pillars, cardinal ridge, teeth, and muscular apophysis is invariably that which characterises *Hippurites gosaviensis*. None of the specimens show every one of these parts with perfect distinctness, but by piecing together the indications furnished by separate individuals the main outlines of the plan can be discovered. The first pillar is circular in section and supported on a much shorter ridge than the second pillar which is more elliptical. The supporting ridges are excessively slender, and that of the second pillar is constantly deflected posteriorly, that is away from the first pillar and from the cardinal ridge. Amongst Douvillé's illustrations the only one representing any tendency to such a disposition is that of a specimen collected by Carez in the Corbières (text-figure 15). The constancy of this character in the Seistan specimens probably represents a racial character. The cardinal ridge is long and slender and terminates somewhat irregularly. The shape of the posterior tooth and muscular apophysis and of their respective alveolæ cannot exactly be made out in any of the specimens owing to the crystalline condition of the calcite filling them; but their relative position can be recognised as being transverse to the first pillar, and agrees therefore with that which characterises *H. gosaviensis*, the posterior muscular apophysis always extending internally beyond the first pillar. Fig. 1*c*, Pl. 14, shows the upper surface of an almost perfect lower valve, of which two side views are also given (Pl. 14, fig. 1*a*, 1*b*). The projections from the upper valve and their corresponding alveolæ are concealed by remnants of the shell substance of the upper valve, but the specimen shows very clearly that the space in front of the anterior pillar is occupied by shell substance,

indicating that the alveola for the muscular apophysis extends further inwards than the extremity of the first pillar, a very characteristic feature of *H. gosaviensis.* The same specimen also shows very clearly the absence of any anterior accessory cavity in front of the cardinal ridge—also a character of this species.

Fig. 2, Pl. 14, represents a somewhat weathered and fragmentary upper valve whose upper surface has been partly polished, showing clearly all the leading features: the cardinal ridge and pillars, the body cavity and scars of adductor muscles, and the position of the teeth and muscular apophysis of the upper valve. The annexed outline drawing will help to understand these features on the photograph:—

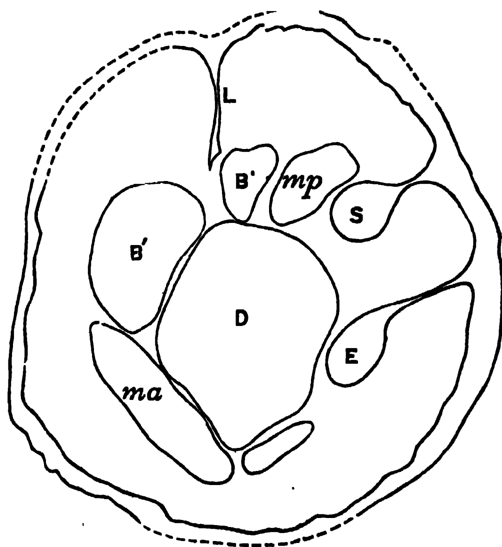


Fig. 1.—Section of *Hippurites gosaviensis.*

(See Pl. 14, fig. 2.)

B', alveola of anterior cardinal tooth; B, alveola of posterior cardinal tooth; *mp*, socket of posterior muscular apophysis; L, cardinal ridge; S, first pillar; E, second pillar; D, body cavity; *ma*, anterior muscular scar.

A curious feature of all the specimens is the silicification of the two pillars, this being the only part of the shell that has undergone this pseudomorphous change.

Pironæa persica, nov. sp.

PL. 15, figs. 1—3.

Description.—The specimens are slender and soon acquire a cylindrical shape with a diameter of 4 to 5 centimetres.

The upper valve, preserved only in one specimen, is conical-depressed, and covered with pustuliform protuberances. The state of preservation is not sufficiently good to ascertain exactly the shape of the pores though they seem to be linear; they are surrounded by polygonal meshes.

Externally the lower valve is ornamented with very angular ribs of greatly varying dimensions. Owing to this irregularity, the grooves corresponding with the pillars and cardinal ridge cannot be distinguished.

Internally, in addition to the pillars and cardinal ridge, there are eight very pronounced inward projections of the internal layer of the shell-envelope. Even in the largest specimens, the spaces between these projections are not subdivided as is usually the case in adult individuals of other species of *Pironæa,* but merely reproduce, in an inverted manner, the shape of the intervening prominences. It is only in the rather broad interspace next the second pillar, and between the pillars and cardinal ridge, that secondary inflections resembling those of other species of *Pironæa,* are to some extent developed.

These internal projections do not in any way correspond with the grooves on the outer surface of the shell, and the outer layer does not adapt itself to the inflections of the inner one. The shell is consequently thicker than is usual for *Pironæa.* The disposition is, in a way, the opposite of that observed in *Batolites* where the inflections occur in the outermost layers, the inner outline of the external envelope remaining unaffected. In the present case, the inflections affect the inner layer of the envelope and not the outer one, while in a normal *Pironæa,* both layers are affected. Nevertheless, the disposition is essentially that of a *Pironæa,* and the absence of deep inflections in the outer layer, together with the absence of secondary inflections in the inner one, suggests that

we are dealing with a type more primitive than those previously described.

The cardinal ridge is broad and well developed, terminating in a blunt point. The first pillar is somewhat shorter than the second; both are supported on stout ridges. Owing to the sectioned specimen having become irregularly stained during the process of fossilisation, these features are not quite so clear as might be desired on the photograph. The annexed outline drawing, fig. 2, will help one to understand them more clearly:—

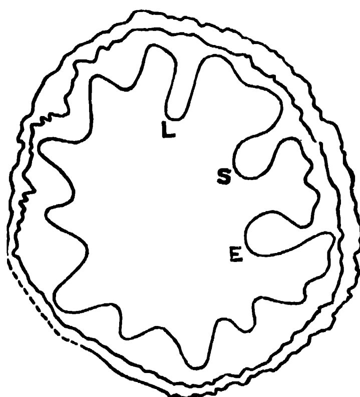


Fig. 2.—Section of *Pironæa persica*.

(See Pl. 15, fig. 3.)

L, cardinal ridge; S, first pillar; E, second pillar.

The disposition of the posterior tooth and posterior muscular apophysis cannot be clearly made out, the corresponding part of the shell being partly destroyed in the sectioned specimen.

Comparison with other species.—This species differs somewhat from its congeners owing to the circumstance, already alluded to, of the inflections affecting but one portion of outer layers of the shell, the disposition being somewhat the opposite of that observed in *Batolites*: while it is the outermost envelope alone that is inflected in *Batolites*, it is only the internal portion of the envelope that is folded in *Pironæa persica*. Moreover, *P. persica* is readily distinguished from adult specimens of the European species *P. polystylus* Pirona, owing to the almost complete absence of secondary

inflections. There is another Asiatic species of *Pironæa*, *P. corrugata* Woodw., the exact locality of which is not absolutely certain, but which occurs together with *Hippurites vesiculosus*, a species closely related to *H. gosaviensis* (Douvillé, *Etudes sur les Rudistes*, pp. 109, 228). This species appears somewhat related to *P. persica* owing to the feeble development of the secondary inflections, but, judging from a photograph taken by S. P. Woodward and reproduced by Douvillé (*Etudes sur les Rudistes*, Pl. XXXII, fig. 14), the manner in which the folds are disposed indicates that the corrugation must extend to the outer layers of the envelope. Moreover, *P. corrugata* is distinguished by its obtuse cardinal ridge and the much smaller interval between the two pillars. The pillars of *P. persica* present, in section, a narrow neck resembling that of an ordinary *Hippurites*, while there is no such constriction in *Pironæa corrugata*.

GEOLOGICAL AGE OF THE HIPPURITE-BEARING BEDS OF SEISTAN.

De Morgan's previous discoveries of Persian hippurites.

The only species of hippurite authentically known from Persia is the Upper Senonian *H. cornucopiæ* Defrance, discovered by de Morgan in the Bakhtyari mountains. The association of a normal hippurite with a *Pironæa* such as occurs in Seistan recalls the association of *Hippurites vesiculosus* Woodward and *H. Loftusi* Woodw. in company with *Pironæa corrugata* Woodw. observed by Loftus presumably at Hakim Khan in the valley of the Upper Euphrates in Asia Minor. The Hakim Khan beds, like others in Europe where a similar association has been observed, are regarded as Upper Senonian. If my identification of one of the Seistan species with *H. gosaviensis* be correct, the age of the Seistan beds is probably different, and more probably uppermost Turonian. This supposition would satisfactorily account for the abnormally primitive characters of *Pironæa persica*.

Hippurites discovered by Loftus presumably in Asia Minor.

The Seistan hippurites probably uppermost Turonian.

It should be noticed however that *Pironæa corrugata* itself shows somewhat primitive characters in the slight development of its

secondary inflections recalling the young stages of the more differentiated *Pironæa polystylus* Pirona. It is quite possible therefore that the Hakim Khan beds belong to an older age than has hitherto been ascribed to them, and that they do not differ much in age from the Upper Turonian hippuritic limestone of Seistan. One of the Hakim Khan hippurites, *H. vesiculosus*, is very closely related to *H. gosaviensis*.

The horizon of the Seistan hippuritic limestone is one that has never yet been distinctly recognised in any part of India, neither amongst the rocks of the Coastal System nor in the geosynclinal areas.

LIST OF ILLUSTRATIONS.

PLATE 13.

Geological sketch-map of Baluchistan.

PLATE 14.

Hippurites gosaviensis Douvillé. Fig. 1, *a*, *b*, *c*: anterior, posterior and upper aspects of an almost complete lower valve. Fig. 2: polished surface of another lower valve. Both specimens from Koh-i-Nahrahu. (Natural size.)

PLATE 15.

Pironæa persica, nov. sp. Fig. 1: complete specimen with upper valve preserved. Fig. 2: fragment of a lower valve. Fig. 3: polished section of another specimen. All three specimens from Koh-i-Nahrahu. (Natural size.)

PLATE 16.

Fig. 1*a*: cast of a Nerinea. Fig. 1*b*: section of the same specimen. Fig. 2: Gen. indet., spec. indet. Both specimens from Koh-i-Maku. (Natural size.)

FUSULINIDÆ FROM AFGHANISTAN. BY H. H. HAYDEN, *Superintendent, Geological Survey of India.* (With Plates 17 to 22.)

Introduction and Stratigraphy.

THE Indian province is strikingly poor in Palæozoic Foraminifera. The only specimens hitherto described are comprised in the meagre collection embracing *Fusulinidæ* (*Fusulina* and *Fusulinella*), *Lagenidæ* and *Lituolidæ* from the Productus beds of the Salt Range.[1] Recently Fusulina limestones have been found both in Burma[2] and in Baluchistan,[3] but the fauna of these has not yet been critically examined. From the Himalayan region not a single Palæozoic foraminifer has been recorded and the recent discovery, in the Bamian Province of Afghanistan, of limestones extremely rich in members both of the *Fusulinidæ* and of the *Miliolidæ* thus acquires considerable interest.

The Bamian limestones are well seen in the precipitous gorge through which runs the road from the Shibar pass to Balula and again in the ravine known as the "dara-i-Khojagár" at about 4 miles to the north-north-east of Taibut, the headquarters of the Bamian district. These localities were visited in the course of rapid traverses and the extremely complicated geological structure of the surrounding country was only very imperfectly elucidated. The foraminiferal limestones, however, are underlain by a series of slate and limestone probably including members of both the Lower Carboniferous and Devonian systems. In the Shibar area there is a great unconformity between the Upper Carboniferous and the next overlying formation which is probably at least as young as Jurassic. In the Khojagár ravine the upper limit of the beds was not seen as it lies on a lofty range which could not be visited; the northern flanks of the same range are composed chiefly of volcanic rocks, but the intervening area has not been explored and consequently the mutual relationships of the two series are unknown.

The age of the foraminiferal limestones, however, is clearly indicated not only by their *Fusulinidæ,* but also by associated

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1 *Pal. Indica,* ser. XIII, Vol. I, 983 (1887).
2 *Rec., Geol. Surv. India,* XXXV, 52 (1907).
3 *Rec., Geol. Surv. India,* XXXI, 165 (1904).

brachiopods which include the characteristic Carboniferous species *Productus punctatus* Martin.

Family: **FUSULINIDÆ** Moeller.

Nature of the shell of the *Fusulinidæ*.

Until recently there was apparently no question as to the nature of the shell of the members of this group, which has been referred by most British rhizopodists from Williamson onwards to the *Hyalina* or *Perforata*, these terms being regarded as synonymous.[1] Quite recently, however, Mr. G. H Girty, in his description of the *Fusulinæ* of the Guadalupe formation of America[2] cast doubts on the generally accepted theory as to the nature of the so-called perforations and was disposed to refer to mineral matter the dark lines hitherto regarded as representing perforations through the shell-wall.

The state of preservation of many of my Afghan specimens has permitted me to examine their shell structure in some detail and I have been led to the following general conclusions :—

(*a*) that the typical fusuline shell was undoubtedly perforate, but

(*b*) that the material of which that shell was composed was not hyaline (vitreous) but porcellanous.

Before discussing the texture of the shell, it is necessary to determine exactly what is meant by the term "porcellanous." It was, I believe, first applied to the Foraminifera by Williamson, who refers to "one group, to which the majority of the *Miliolæ* belong" in which "the shell consists of an opaque, calcareous substance having a porcelainous aspect, and presenting when seen by transmitted light, a rich amber or brown colour. Such varieties are rarely if ever foraminated."[3] Subsequently, in referring to porcellanous forms, Carpenter definitely stated that "no structure of any kind" could "be detected in this kind of shell-substance, which is apparently homogeneous throughout."[4] Most rhizopodists seem

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1 J. J. Lister: "The Foraminifera"; in *Proc. Roy. Inst. Gt. Britain,* Vol. XVIII, Part III, No. 101, p. 489 (1909).

2 *U. S. Prof. Paper,* No. 58, p. 61 (1908); see also *Amer. Journ. Science,* ser. IV, Vol. XVII, 238 (1904).

3 W. C. Williamson: On the recent Foraminifera of Great Britain, p. xi; *Publications of the Ray Society* (1858).

4 Introduction to the study of the Foraminifera, p. 44; *Publications of the Ray Society* (1862).

to have been content to accept this view without question.[1] Bütschli,[2] however, pointed out that it was not strictly correct and defined the texture of *Orbitolites* and *Alveolina* as "ein sehr feinfaserig-körniges Wesen der Schalenmasse." None of the recent literature on the Foraminifera, to which I have had access, throws any further light on the ultimate structure of the shell-substance of the *Porcellanea* and I have searched in vain for either a definition or illustrations of the so-called "porcellanous" material. It has therefore seemed worth while to put my observations on record.

The typical transverse section of the shell of *Fusulina* is familiar from the excellent figures given by Schellwien, Schwager and others, and will be readily recognised in Plate 17, fig. 1, which is taken from a photograph of an Afghan specimen.

Structure of the shell-substance.

Under the microscope, by transmitted light, whenever the intimate structure can be seen, the transverse section shows a series of light and dark bands, one series of which represents the shell and the other the perforations. Corresponding to this transverse section there are two distinct types of horizontal (tangential) section; each consists of a net-work, but in one type the net-work is dark and the intervening spaces more or less colourless and transparent, whilst in the other the spaces are darker than the mesh-work (see Plate 17, figs. 3 to 7). Either of these horizontal sections will give a transverse (vertical) section composed of alternating light and dark bands, but if we are right in regarding the net-work as the shell and the intervening spaces as perforations,[3] the light and dark bands in the vertical section will represent respectively shell and perforations in the one case and perforations and shell in the other. Whether the net-work representing the shell be relatively light or dark, its structure, which can be clearly made out in thin sections, is always the same and is typically "cryptocrystalline"; under high powers of the microscope the shell-substance resolves itself into an extremely fine-grained mosaic of grains of a colourless, anisotropic mineral which is soluble with effervescence in cold,

[1] *Challenger Reports:* Zoology, Vol. IX, p. 50 (1884).
[2] Dr. H. G. Bronn's *Klassen und Ordnungen des Thier-Reichs,* I, 23 (1880-82).
[3] For proof that these are perforations see below, p. 233.

dilute hydrochloric acid and is presumably calcite.[1] In reflected light this material has the white, chalky appearance usually regarded as characteristic of the shells of the *Porcellanea.* This has led me to examine closely the structure of certain imperforate shells which occur in the same beds as the *Fusulinæ* and which I refer to the *Miliolidæ* (*Miliolina*); I have found this to be identical. Lest I should have been misled by subsequent alteration of the material of the shell, I have examined several specimens of *Alveolina* from the Laki beds of Sind,[2] of *Miliolina* from the "miliolite" of Kathiawar and also a recent specimen of *Biloculina depressa* var. *murrhyna* Schw. from the Arabian Sea near the Laccadive Islands.[3] The only difference between the recent and the fossil forms is that, in transmitted light, the latter are without the yellowish-brown colour characteristic of recent members of the *Porcellanea*;[4] but in all cases the material forming the shell proved to be the same in other respects and to be a cryptocrystalline mass, breaking up, under high powers of the microscope, into a very fine mosaic of what I take to be calcite. It is clear, therefore, that the shell of *Fusulina* was similar to that of *Miliolina* and was porcellanous.

According to the usually accepted ideas, therefore, the shell of *Fusulina* should also be imperforate.[5] Girty appears inclined to adopt this view. I have already pointed out that in tangential sections of the shell, the cellular interstices in the net-work contain either a colourless and translucent mineral or else what at first sight appears to be a mass of brown ferruginous material remaining opaque even in thin sections.

Perforations.

In the first case the mineral filling these cellular areas is typical crystalline calcite, forming a mosaic which is very coarse in comparison with that composing the shell-substance. The original chamberlets of the specimen are also filled with a coarse calcite mosaic, parts

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1 I have not been able to satisfy myself beyond possibility of doubt that this material is calcite; both my colleague Mr. G. H. Tipper and I endeavoured to prove it by means of Lemberg's solution, but the results were not conclusive.

2 I am indebted for these specimens to my colleagues, Messrs. E. Vredenburg and G. H. Tipper.

3 This specimen, for which I am indebted to the kindness of Dr. N. Annandale, Superintendent of the Indian Museum, was one of a series of foraminifera which had been named by Mr. F. Chapman.

4 This colouration of the recent shells was referred by Carpenter (*op. cit.*, p. 44) to animal matter and one would naturally expect it to be absent from fossil forms.

5 Brady: *op. cit.*, pp. 55, 131.

of which are sometimes in optical continuity with the material filling the cellular areas. As the chamberlets were originally occupied by sarcode, the crystalline calcite now taking its place must be subsequent in origin to the shell-substance and consequently the material which is in optical continuity with this calcite is presumably also subsequent.

In most instances, especially in the case of *Fusulina*, the thickness of the cell-walls is less than the diameter of the perforations; hence, in cases in which these perforations are filled with crystalline calcite, the shell appears to consist of calcite traversed by a number of dark lines. The structure of the shell-wall as a whole is in fact exactly analogous to that of a honeycomb in which the wax represents the cryptocrystalline shell-substance and the honey the subsequently deposited calcite. It is not unnatural, therefore, that at first sight the calcite should be regarded as the true shell and the dark lines as perforations. This was evidently the view adopted by the earlier observers, including Carpenter,[1] and it seems to have been accepted without question by palæontologists in general.

In the case in which the spaces in the cryptocrystalline meshwork contain material darker than the enclosing shell-substance, the brown opaque material is in my specimens often confined to the sides of the tubular perforations, the centre of which is filled with colourless and translucent material, presumably calcite. This is shown in Pl. 17, figs. 6 and 7, which represent a thin section of a fragment of shell of *Fusulina uralica* Krotow. The brown material is possibly a hydrated oxide of iron which has been deposited on the sides of the perforations.

This section (figs. 6 and 7) is further interesting from the fact that it has been cut not quite tangentially but slightly obliquely to the surface of the shell, as along the line *a* . . . . . *a* (text-fig. 1); it thus exposes a section of the roof as well as of the septum, and both of these are seen to be composed of the same cryptocrystalline (porcellanous) material, the roof differing from the septum merely in being perforated, whilst the substance composing the meshwork of the roof of any one chamber is perfectly continuous with that forming the imperforate septum of the same chamber.

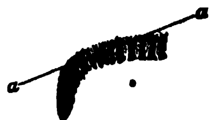


Fig. 1. Section of shell-wall and septum of *Fusulina*.

[1] *Op. cit.*, p. 305, and Pl. XII, fig. 26.

At first sight, particularly with low powers of the microscope, the shell of the *Fusulinidæ* appears to be a continuous band, quite distinct from, and usually darker than, the material subsequently deposited in the empty chamberlets. The cause of this deceptive appearance is the minuteness of the perforations, which is such that in all ordinary sections the thickness of the rock slice is greater than the diameter of any one of the perforations. With care, however, it is possible to grind down sections of the shell of *Fusulina* until their thickness is not greater than the diameter of the perforations, when the latter are found to correspond to breaks in the cryptocrystalline material of the shell-wall and to contain crystalline calcite similar to, and sometimes in optical continuity with, that filling the chamberlets.[1]

Supposed exogenous outer layer.

Both Messrs. Girty[2] and Yabe[3] speak of a dark outer superficial layer in the shell of *Fusulina* which they regard as imperforate and which Mr. Yabe is inclined to look upon as exogenous and continuous with what he calls the "median lamella." I was at first disposed to accept this view, but I have found that in very thin transverse sections of the shell the perforations can often, though not invariably, be seen to run completely through the wall. I have examined a large number of sections, not only of *Fusulina*, but also of *Schwagerina* and *Neoschwagerina* (including "*Doliolina*" Schwager), and I have no doubt that the comparative opacity of the supposed exogenous layer is to be attributed largely to the fact, already illustrated by Schellwien,[4] that towards the outer surface the perforations appear to dichotomise; this would no doubt result in an increase of their number but also in a considerable decrease in their size; hence a section which is thin enough to show clearly that the inner part of the wall is perforate may still be, and usually is, too thick to enable one to detect the presence of the much more minute perforations in the outer part of the wall, since each perforation, though possibly open to one side, is overlapped by cell-walls on the other and thus appears dark. This will be

[1] This latter condition cannot often be observed, since the secondary calcite which now fills the chamberlets and pores, consists of a very fine-grained mosaic of variously oriented crystals, each of which is usually too small to give definite evidence of its extension from a chamberlet into a perforation.

[2] G. H. Girty: *Amer. Journ. Sci.*, *loc. cit.*

[3] *Journ. Coll. Sci. Imp. Univ. Tokyo*, Vol. XXI, Art. 5, p. 7 (1906-07).

[4] *Palæontographica*, Vol. XLIV (1897), Pl XXII, figs. 3, 5, 6,

readily understood when it is realised that the average diameter of one of the perforations on the inner surface of *Neoschwagerina craticulifera*, for instance, is not more than 5μ, whilst those in the outermost layer are very much smaller (Pl. 21, fig. 6).

Whether the apparent dichotomising of the perforations is due to the addition, in parallel growth, of subordinate cellules in the outermost layer, or to an actual branching of the walls of the perforations, I have been unable to decide owing to the extreme minuteness of the structures. So far as we are concerned at present the point is immaterial; in either case the effect is the same. The reduction in size of the perforations is not accompanied by a proportionate decrease in the thickness of their walls; consequently the outermost layer contains a considerably larger amount of shell-substance than the inner parts, and when, as is usually the case, the perforations are filled with translucent calcite, appears darker than the rest of the shell-wall and, except in very thin sections, seems to be a continuous layer of dark imperforate material. Even in sections which are thicker than the diameter of the perforations, the perforate nature of the shell can be detected by using a high power of the microscope and focussing first on the upper side of the slide and then gradually on to deeper parts, when the continuous appearance of the band will be seen to be due to overlapping of shell over perforations. In my specimens these observations can be made most satisfactorily in reflected light, under which the shell-substance appears white and chalky and the perforations, which are usually filled with calcite, become dark bands. I have also noticed in several sections a thickening of the shell-walls of the perforations both at the outer and the inner surface of the shell. This will of course tend to reduce the size of the openings of the perforations and to increase the amount of shell-substance in the outer, as well as in the innermost layer.

In some sections, in which the perforate character of the outermost layer is quite evident, there are small portions of it in which it is impossible to detect the presence of perforations. It is difficult to see what purpose could have been served by perforations in the inner part of the shell-wall if they were not to pass through the outer layer as well. The most plausible explanation of their apparent occasional absence from the outer wall seems to be that when the shell of each chamber was nearing completion, the outer wall was, as we have already seen, strengthened either by the addition of partitions to, and

the consequent subdivision of, the perforations or by the bifurcation and also by the thickening of their walls. In this way a certain number of the perforations were either intentionally or accidentally closed.

Imperforate nature of the septa.

That the outer shell-layer is not a subsequent exogenous deposit formed on the *floor* of the chamber is evident from the fact that it is continuous with Yabe's "median lamella," which is the outer surface of the septum. Schellwien (*op. cit.*, p. 239) was the first to establish the fact that the septum was formed by the bending of the wall from a spiral to a radial direction, but in some cases he too appears to have taken the calcite-filled perforations for the shell-substance and the dark cell-walls for perforations.[1] Thus he speaks of a dark line of division between the walls of adjacent chambers and suggests that it may possibly be due to want of adhesion, that is to say that it represents a space, between the two. This dark line, however, is clearly Yabe's "median lamella"; it is composed of shell-substance and appears to be invariably imperforate. It extends downwards in a radial direction beyond the rest of the shell-wall and in most cases broadens out considerably to form the base of the septum (Pl. 21, fig. 5). This thickening of the imperforate material is exactly analogous to that already noticed on a very much smaller scale in the walls of the perforations. A similar addition of imperforate material is often observed on the secondary septa in *Neoschwagerina* (see below, p. 248). Yabe has already pointed out that the material thus added is perfectly continuous with the rest of the shell and is not, as Schellwien supposed (*op. cit.*, p. 240, figs. 4 and 6), separated from it by a hard line.[2] It is in fact merely a local continuation of the shell-growth added presumably to strengthen the shell, hence its imperforate character.

[1] His views are not clear. In the figures given on pp. 239 and 240, he shows the septum as a transparent tongue, which he describes as part of the shell-wall and therefore presumably regards as calcite; consequently the dark lines must represent the perforations. On the other hand, on p. 241, he distinctly attributes to the absence of pores the darker shade of the exogenous growth and on p. 242 he refers the clear spaces in his horizontal sections (Pl. XXII, figs. 5 and 6) to pores.

[2] At the same time as already noticed by Girty in the case of *Fusulina elongata* Shumard (*op. cit.*, p. 63), there is a distinct tendency in the *Fusulinidæ* for adjacent whorls to split off from one another: this occasionally leads to a dark line of division when the gap between any two whorls is very narrow.

That the material is imperforate is clearly seen in sections in which both the radial and spiral parts of the shell-wall have been cut through approximately horizontally as in Pl. 17, fig. 7 in which the perforate wall can be seen to merge into the lower part of the septum. In the more minutely perforate forms (*Schwagerina* and *Neoschwagerina*) the outermost layer of the septum and its extension below the level of the rest of the shell-wall are also imperforate.

I am aware that both Schellwien[1] and Yabe[2] have stated that in some cases the septa are perforate; this is no doubt true for so much of the upper part of the septum as is formed by the bending-down or by the thickening of the perforated wall of the shell, but its outer layer—Yabe's "median lamella"—as well as its broad basal portion, is imperforate. It is difficult to see what useful purpose would be served by perforations in the septal face; they would certainly impair its strength and, in view of the fact that it was pierced by oral apertures (see Pl. 17, fig. 6), they would appear to be superfluous.

Systematic position of Fusulina.

If a vitreous shell is to be regarded as an essential characteristic of the *Nummulinidæ*, then we must remove the *Fusulininæ* from that family. This will accord with the classification followed by Continental rhizopodists, but not with that usually adopted in Britain. In that employed by Zittel[3] the *Fusulinidæ* are given the rank of a family and grouped under the sub-order *Vitro-calcarea*. This again is unsuitable, since the shell of *Fusulina* has now been found to be porcellanous. The exact taxonomic value of shell-texture and of shell-composition in the *Foraminifera* has long been a matter of discussion among rhizopodists[4] and no classification involving sub-orders based on these characters is likely to meet with general acceptance. The method adopted by Brady of subdividing the order directly into families seems to be the only feasible arrangement at present, but, as already pointed out, the *Fusulininæ* must be removed from the

1 *Op. cit.*, Pl. XXII, fig. 4.

2 *Journ. Coll. Sci., Imp. Univ. Tokyo*, XXI, Art. 5, p. 2 (1906-07).

3 Text-book of Palæontology (translated by Eastman), 1900.

4 See among other papers: Sollas, W. J., in *Geological Magazine*, Dec. II, Vol. IV, 105 (1877); Carter, H. J., in *Ann. Mag. Nat. Hist.*, ser. iv, Vol. XIX, 205 (1877); Brady, H. B., in *Challenger Reports*, Zoology, Vol. IX, pp. 48-77 (1884); Neumayr, M., in *Sitzungsber. der kais. Akad. Wien*, XCV, 156 (1887).

family *Nummulinidæ*. It seems preferable to follow most Continental rhizopodists in allowing them the status of a family, the *Fusulinidæ*. At present this family occupies an unique position in comprising the only forms known to be both porcellanous and perforate.

I do not propose to make any attempt to define the systematic position of the *Fusulinidæ*, but I wish to draw attention to the close relationship between the shell of *Fusulina*,—with its subgenera *Schwagerina* and *Neoschwagerina*,—and that of *Alveolina*; it is no longer merely one of identity of shape but also of composition and texture. In fact, the only difference now remaining between the *Fusulinidæ* and the *Alveolininæ* is the perforate character of the former. For purposes of distinction this feature is no doubt valuable, but I am inclined to think that its importance from a phylogenetic point of view may have been overestimated. The descriptions given below of species of the *Fusulinidæ* from Afghanistan will show that there is a distinct tendency towards obliteration of the perforations in the more complicated, and therefore presumably the more highly developed, forms; thus in *Fusulina* only the septa are imperforate, in *Neoschwagerina* the amount of imperforate material is increased in the simpler forms, such as *N. craticulifera* Schw., by additions to the auxiliary septa, whilst in *Neoschwagerina* (*Sumatrina*) *annæ* Volz, the perforations appear to be almost completely obsolete, and the shell almost entirely imperforate. From this type to the wholly imperforate *Alveolina* the transition would seem perfectly simple.

Genus: **Fusulina** Fischer von Waldheim.

In the year 1877, V. von Moeller introduced the genus *Schwagerina* for more or less globular forms of *Fusulina* with simple, straight, unfolded septa.[1] It was subsequently reduced to the rank of a subgenus by Schellwien,[2] who subdivided the genus *Fusulina* into three subgenera, namely:—

Schellwien's classification.

(*a*) *Fusulina* (*sensu stricto*);

[1] *Neues Jahrbuch für Min., Geol. und Pal.*, 1877, *p.* 143.
[2] *Palæontographica*, XLIV (1898), p. 238.

(*b*) *Schwagerina :* fusiform or spherical, with wavy ("hin und her gebogene") or straight septa; "basal skeleton" either entirely absent or only imperfectly developed. Type: *Sch. princeps* Ehrenberg;

(*c*) *Moellerina :* a *Schwagerina* with a clearly developed "basal skeleton." Type: *Moellerina lepida* Schwager.

The name *Moellerina* was afterwards found to be preoccupied and Schellwien renamed his new subgenus "*Doliolina*."[1]

Yabe's classification.

Recently Mr. H. Yabe split up Schellwien's subgenus into two, restricting the name *Doliolina* to forms with only two kinds of septa, *viz.*, "primary septa" and "basal skeletons" and introducing a new subgeneric name "*Neoschwagerina*" for species having subordinate or "auxiliary" septa intercalated between the primary ones. He thus recognises three types of septa, namely, "primary," "auxiliary" and "transverse."[2]

Septa of the Fusulinidæ.

The primary septa run from end to end of the shell, their trace on the surface being the septal line; the auxiliary septa are defined as parallel to the primary, whilst the transverse septa are at right angles to both the primary and auxiliary.

A reference to Pl. 22, figs. 8 to 14, which represent longitudinal and transverse sections of *Neoschwagerina* (*Sumatrina*) *annæ* Volz, will show that in this species there are at least two sets of transverse septa, one of which is always more important than the other; in order to differentiate between these two another term must be introduced. Since the primary septa extend from end to end of the shell in the plane of the axis, I suggest for them and for all septa parallel to them, the term *meridional* and propose to name Yabe's "primary septa" *primary meridional* and his "auxiliary septa" *auxiliary meridional.* Similarly the septa which lie at right angles to the axis might be termed *equatorial* rather than transverse and by extension of the term "auxiliary" to include also septa at right angles to the axis, we have *primary equatorial* and *auxiliary equato-*

1 See Futterer's *Durch Asien*, III, 129 (1903); also *Schriften der Phys.-ökon. Gesellschaft zu Konigsberg*, XLIII (1902), p. 67.

2 *Journ. Geol Soc., Tokyo*, X, No. 113 (1903), p. 5; *Journ. Coll. Science, Imp. Univ. Tokyo*, XXI, Art. 5, p. 2 (1906-07).

rial septa. This nomenclature is more elastic than that employed by Yabe, since the auxiliary septa in either plane will be capable of indefinite subdivision into "secondary," "tertiary," etc. Applying this nomenclature to Yabe's subdivision of von Moeller's genus *Schwagerina*, we have—

(1) *Schwagerina:* only primary meridional septa;
(2) *Doliolina:* primary meridional and "basal skeleton" (see p. 13);
(3) *Neoschwagerina:* primary and auxiliary meridional, also equatorial septa.

Although Yabe has noticed the difference between what I propose to call the primary equatorial and the auxiliary equatorial septa, he has not given it subgeneric value. If, however, we follow out his principle of classification to its logical conclusion, we ought to include in *Neoschwagerina* only forms with primary and auxiliary meridional and primary equatorial septa and create a new subgenus to receive his species *Neoschwagerina globosa.* We should also have to retain as a subgenus Volz's genus *Sumatrina*, which is defined as embracing "spindelförmige Fusuliniden mit einem aus je 2-4 Längs- und Querreifen bestehenden Dachskelet."[1] The result of this minute subdivision is to reduce the subgenus to the rank of a species.

Before offering what appears to me to be a more rational classification of the genus *Fusulina*, it will be desirable to draw attention to the true form and nature of the so-called septa. I have already shown (*supra*, p. 237) that the primary meridional septum is composed partly of the perforated shell-wall and partly of imperforate material forming an outer layer to this part of the shell and extending down to the floor.[2] In the subgenera with straight septa [*Schwagerina* (*sensu lato*)] the septal face is pierced near the base by numerous oral apertures and the lower part of the septum thus becomes a series of pillars. Towards their bases these pillars often splay out, being widened by an exogenous growth of imperforate material, which is occasionally more vigorous in certain directions than in others and may form a series of ridges of quite appreciable height extending along the floor of a chamber between corresponding pillars

[1] "Zur Geologie von Sumatra" in *Geol. und Pal. Abhandlungen,* X, ii, p. 98 (1904).
[2] Verbeek restricts the term "septum" to this outer layer; see Verbeek and Fennema: *Description geol. de Java et Madoura,* II, 1135 (1896).

of successive septa; an example of this mode of growth is *Schw.* (*Doliolina*) *lepida* Schwager. The septa may be compared to curtains of parallel rows of stalactites hanging from the roof of a cave, each stalactite extending down to join its corresponding stalagmite, which may be a narrow column of approximately the same diameter as the stalactite or may be wider and may even spread out over the floor until it extends from curtain to curtain.[1]

The "basal skeleton."

This imperforate exogenous material, which I regard as merely an extension of the basal part of the primary meridional septum constitutes the so-called "basal skeleton (*Basalskelet*)" of *Schwagerina* and it is on account of the varying forms taken by this outgrowth that Schellwien split up von Moeller's genus *Schwagerina* into two; his *Doliolina*, as represented by his type *D. lepida* Schwager, being merely a form in which the exogenous outgrowth from the base of the primary meridional septum is very conspicuous. This character, which is clearly illustrated in the figures given by Schwager,[2] is not in my opinion of subgeneric value, especially as it is generally admitted that there is a perfect gradation between *Schw. princeps* Ehrenberg and *Doliolina lepida* Schw.[3] My specimens of Afghan *Schwagerinæ* have even led me to doubt the validity of *Schwagerina verbeeki* Geinitz as a species distinct from S. *princeps* Ehr. (*infra*, p. 243). On Plate 18, figs. 2, 3, 4 and 6 represent sections of specimens, which, so far as could be judged from external characters, all belong to the same species. Figs. 2 to 4 represent sections cut approximately parallel to the axis, whereas that shown in fig. 6 is somewhat oblique.[4] A feature which appears to be common to all *Schwagerinæ* of this type is the frequent obliquity of the septa, which tend to take a spiral rather than a radial direction with regard to the central chamber (figs. 1, 5 and 6). Hence, according to the degree of obliquity of any particular septum a thin section parallel to the axis may include either the whole septal face or only the upper, middle or lower part respectively (see Pl. 18, figs. 2 to 4). Furthermore, a section may pass through a chamber without cutting

[1] This comparison is used merely for purposes of illustration. The septa are not in any sense analogous to stalactites either in their nature or their mode of origin.

[2] Richthofen's *China*, Vol. IV. Pl. XVIII. figs. 3. 6-11.

[3] Schellwien, *op. cit.*, p. 257.

[4] In dealing with such extremely minute specimens it is impossible to make certain of cutting a section absolutely parallel to any particular direction.

a septum at all. A section taken parallel to the axis through *a..a* (Pl. 18, fig. 1) would miss almost every septum, whereas one through *b...b* would cut a septum in almost every whorl; consequently it would be possible to obtain from a single specimen of *S. princeps* Ehr. either (*a*) a section from which the "basal skeleton" was entirely absent or (*b*) one in which traces of this were to be seen on every whorl [cf. *Sch.* (*Doliolina*) *verbeeki* Geinitz], or (*c*) any intermediate stage between these two extremes. The so-called "basal skeleton" cannot therefore be used as a means of distinction between these two species and is certainly not a feature of subgeneric value. For this reason I propose to discard Schellwien's subgenus *Doliolina*.

Definition of *Schwagerina*.

The forms comprised under the subgenus *Schwagerina* may be defined as *Fusulinæ* with only primary meridional septa which are either straight or are folded only at the ends. These septa are of one type only, *viz.*, primary meridional; there is frequently an outgrowth of exogenous material from the base of the septa and this may extend completely across the floor of the chambers, either as a flat deposit or in the form of parallel ridges at right angles to the primary meridional septa.

Definition of *Neoschwagerina*.

Yabe's genus *Neoschwagerina* differs from *Schwagerina* in having at least one other set of septa, at right angles to the primary meridional series. For these I have proposed the term *primary equatorial*. In addition to these Yabe mentions a third set, *viz.*, his "auxiliary septa," for which I have suggested the term *auxiliary meridional*; to these a fourth set, *auxiliary equatorial*, may be added.

The "Dachskelet."

Each of these four types of septum is formed in the first instance by the downward growth of the inner side of the perforated shell-wall and may be enlarged, like the primary meridional septum, by exogenous additions of imperforate material. All the septa in fact belong to what German authors have called the "Dachskelet" in contradistinction to the "Basalskelet." I therefore propose to include in the subgenus *Neoschwagerina* those forms which differ from *Schwagerina* by the possession of equatorial, as well as meridional, septa. At least one (primary) series of each is essential; and auxiliary septa of either kind may be present.

Designation of the subgenus.

In employing Yabe's name *Neoschwagerina* for these forms I may perhaps be acting not strictly in conformity with accepted rules of nomenclature, since he defines his subgenus as one having three kinds of septa, thereby including auxiliary meridional septa among its essential features. I have found among my Afghan specimens one form in which both sets of primary septa are well developed, but an auxiliary series is either undeveloped or only quite rudimentary and if Yabe's subgenus cannot be made sufficiently elastic to include this form, it will be necessary either to introduce a new term for the enlarged subgenus and discard Yabe's name, or else make a new subgenus out of this single Afghan form. The latter alternative would involve the creation of a large number of new subgenera each characterised by having one more auxiliary septum than its predecessor; this would be mere genus-mongering and not only superfluous but impracticable, since in a single specimen the number of auxiliary septa of either type is not constant and may vary from one in the innermost whorls to as many as four in the outer. On the other hand, I should be loth to discard Yabe's apposite term *Neoschwagerina*, but should its employment, in a sense slightly wider than that implied by its original definition, be likely to lead to confusion, I would propose the name *Cancellina*,[1] as a subgeneric term for species with equatorial, in addition to meridional, septa. In the term "septa" I include only those partitions which originate from the bending down or the downward growth of the shell-wall; these may or may not be enlarged by the addition of imperforate material, which may extend down to, and over, the floor, thus forming a "basal skeleton," which, however, is subsequent to, and an outgrowth from, the septa and is not an independent feature.

DESCRIPTION OF SPECIES.

Fusulina uralica Krotow.

PLATE 17, figs. 6 and 7, PLATE 19, figs. 1—12.

1898. F. uralica P. Krotow:—"Geologische Forschungen in den Gebieten von Tscherdyn und Ssolikamsk": *Mem. Com. Geol. St. Petersburg*, VI, (1888), p. 551, and Pl .II, figs. 2-6.

[1] *Cancelli* = lattice.

Shell spindle-shaped, highly vaulted in the centre but thinning rapidly towards the ends, which frequently terminate in sharp points. The ornamentation consists of numerous longitudinal striæ, set closely together and representing the traces of the septa; in larger specimens there are also several longitudinal ridges and furrows, occurring at irregular intervals. At either end of the shell the ridges and striæ converge and are twisted in a sense opposite to that of the spiral of the shell. The ratio of length to breadth increases with the size of the shell; in my Afghan specimens it ranges from 1·75 to 2, as will be seen from the following measurements of a number of specimens:—

Length.	Breadth.	Ratio.
7 mm.	4 mm.	1·75
7 „	4 „	1·75
8 „	4½ „	1·78
9 „	4½ „	2
10 „	5 „	2
11 „	5½ „	2
11 „	5½ „	2
12 „	6 „	2
13 „	6½ „	2
14 „	7 „	2

Measurements made on a longitudinal section of a specimen of medium size, gave ratios $(\frac{\text{length}}{\text{breadth}})$ of 1·75, 1·95 and 2 for the second, third and fourth whorls of the shell, respectively.

Internal characters.—The internal characters of the species will be readily seen from Pl. 19, figs. 7—12. The chief features are the slow rate of evolution of the whorls and the large number of the septa. The central chamber is approximately spherical, and ranges, in my specimens, from 0·4 to 0·8 mm. in diameter. Measurements made on a number of specimens showed the rate of evolution to be

variable, but slow: these measurements, which are given below, indicate the *total* breadth of the shell at successive stages of growth:—

I.	II.	III.	IV.	V.
·45 mm.	·45 mm.	·50 mm.	·60 mm.	·80 mm.
·70 „	·70 „	·75 „	·95 „	1·10 „
1·05 „	1·15 „	1·35 „	1·60 „	1·75 „
1·55 „	1·85 „	2·00 „	2·35 „	2·50 „
2·25 „	2·60 „	2·75 „	3·35 „	3·25 „
3·05 „		3·65 „		4·15 „
3·90 „		4·65 „		5·10 „

The largest number of whorls observed is eight. The septa are very numerous, there being between 40 and 50 in the fourth whorl, about 50 in the fifth and over 50 in the 6th; they are much folded with the result that in transverse sections they either coalesce or appear to be grouped in pairs. The aperture is not always clear but appears to be about $\frac{1}{11}$ of the length of the shell in the inner whorls.

Locality.—From the Fusulina limestone of Khojagár dara, at about 4 miles north-north-east of Taibut (Bamian).

Remarks.—There can, I think, be no doubt that my Afghan specimens belong to Krotow's species, *F. uralica*, with which they agree exactly in almost all their characters. The only points in which they show any difference from that species are the size of the central chamber and the number of septa. According to Krotow, the central chamber of the species is small (about 0·2 mm.), whereas in my specimens it ranges from 0·4 mm. to 0·8 mm.; the average taken from eight specimens, is a little over 0·5 mm.; if, however, the section from which the measurements were taken, were cut at a little distance on either side of the centre, the apparent width of the chamber might easily be reduced to 0·2 mm.; Krotow's figures are not very clear, but the only one (*viz.*, fig. 5) which appears to show the central chamber is slightly oblique to the long axis of the specimen and may have been cut at some little distance from the centre. It is possible that Krotow's specimens may

represent the microspheric and mine the megalospheric form of the species. In certain cases of supposed dimorphism in *Fusulina,* illustrated by Schellwien,[1] the difference in size of the central chamber is even less than that between Krotow's specimens and mine, but it does not seem to me sufficiently marked to warrant the assumption of dimorphism. According to Krotow, the number of septa in the sixth whorl is 40 and over; in my specimens there is a larger number, but the difference is not great and certainly does not warrant the creation of a new species.

The nearest allies of the Afghan specimens are *F. multiseptata* Schellwien and *F. complicata* Schellwien, both of which are very similar in their internal characters to *F. uralica* Krot., but differ widely from it in external shape.

Fusulina elongata Shumard.

PLATE 17, figs. 3—5, PLATE 20, figs. 1—12.

1858-9. *F. elongata* Shumard. *Trans. Acad. Sci. St. Louis,* I, 297, 388 (1860).

1908. *F. elongata* Girty. The Guadalupian Fauna: *U. S. Geol. Survey Prof. Paper* 58, p. 62.

Shumard's scanty description of his species has been considerably amplified by Girty, whose beautiful figures have enabled me to recognise *F. elongata* as the most plentiful among my Afghan *Fusulinidæ.* As in the Guadalupe Mountains of Texas, so in Bamian, whole masses of rock are composed almost exclusively of this species.

In transmitted light under the microscope my sections are identical with those figured by Girty, and there is little to add to his description beyond the fact that the size is even greater than he has stated, my largest specimen being almost three inches long. Unfortunately this specimen occurs on the surface of a slab of limestone from which a considerable part of the fossil has been weathered away and although its very large size suggests that it may be the microspheric form of the species, this cannot be verified since the central chamber has disappeared (Pl. 20, fig. 12).

[1] *Palæontographica,* Bd. 55, Pl. XVI, figs. 5 and 7.

In Bamian *F. elongata* occurs at two horizons, one a little below and the other a little above, the horizon of *Productus punctatus* Martin. The forms from the lower horizon are as a rule larger and have a greater number of whorls than those from the higher but do not otherwise differ from them.

The appearance of the shell of his specimens led Girty to the conclusion that it was not perforated. From his description I am inclined to think that the dark rods to which he refers are the actual shell and the intervening areas the perforations. Pl. 17, figs. 3—5 show quite conclusively that the shell of the Afghan specimens of *F. elongata* was perforate.

Neoschwagerina craticulifera Schwager.

PLATE 21, figs. 1—7.

1883. *Schwagerina craticulifera* Schwager. Richthofen's *China,* Bd. IV, p. 140.

1903. *Neoschwagerina craticulifera* Yabe. *Journ. Geol. Soc. Tokyo,* Vol. X, No. 113.

A glance at Plate 21 will show that the Afghan specimens correspond exactly with Schwager's type of the species. There are three sets of septa, a primary and secondary meridional and a primary equatorial. The secondary meridional septa differ from the primary in being formed merely by a downward thickening of the shell-wall, the lower part of which becomes imperforate. The radial strip of imperforate material[1] which is characteristic of the primary meridional septa, is not seen in either the auxiliary meridional or in the equatorial septa.

Plate 21, figs. 5 and 6 represent transverse sections of part of the shell of this species.

The central chamber of my specimens is very small (70 μ to 90 μ), corresponding in this respect with Schwager's type of the species. Recently, however, Yabe has published an illustration of a transverse section of what is evidently *N. craticulifera*, but which has an unusually large central chamber (473 μ)[2]; this is clearly a case of dimorphism, Schwager's type and my Afghan specimens

[1] Yabe's "median lamella."

[2] This figure based on measurement of the published illustration.

representing the microspheric form, whilst Yabe's specimen is megalospheric.

Another interesting feature is illustrated in Pl. 21, figures 2 and 7, in which the equatorial septa are seen to be pierced at either side of the primary meridional septum by a passage running meridionally along the shell. This is exactly analogous to the structure of *Alveolina* referred to by Carpenter under the term "longitudinal galleries";[1] fig. 8 represents a photograph of the transverse section of *Alveolina* (*Flosculina*) *pasticillata* Schwager from Sind, and shows these galleries.

Neoschwagerina primigena n. sp.

PLATE 22, figs. 1—7.

This is the simplest form of *Neoschwagerina* and is characterised by a single set each of meridional and equatorial septa.

I have not been able to extract any specimens from the hard matrix in which they occur and the general shape and external appearance can only be deduced from sections, from which they appear to have been similar to *N. craticulifera* Schw., from which this species differs by the absence of well-marked auxiliary septa. In some instances, however, I have observed transverse sections with such septa, but they are quite rudimentary and are found only in the outermost whorls.

In section this species also recalls *Sch. lepida* Schw., but differs from it in having true equatorial septa, which are formed by the downward growth of the perforate shell-wall and are quite different to the raised ridges of imperforate material which in *Sch. lepida* run out from the base of the primary meridional septa. On the other hand, the transverse section might well pass for that of *Sch. lepida.* The form, therefore, is intermediate between *Sch. lepida* and *N. craticulifera*, differing from the former in the presence of equatorial septa and from the latter in the general absence of auxiliary meridional septa.

The number of whorls is comparatively small, the usual number being from six to nine. The central chamber is large, sometimes as much as 300 μ in diameter; my specimens are possibly all megalospheric.

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[1] *Op. cit.*, p. 101.

Neoschwagerina annæ Volz.

PLATE 22, figs. 8—14.

1904. *Sumatrina annæ* Volz. Zur Geologie von Sumatra: *Geol. und Pal. Abhandlungen*, Bd. X, Heft 2 (1904).

1906-07. *Neoschwagerina annæ* Yabe. *Journ. Coll. Sci., Imp. Univ. Tokyo*, Vol. XXI, Art. 5, p. 3.

In the year 1904 Dr. W. Volz described under the name of *Sumatrina* a new genus of *Fusulinidæ* represented by a single species, *S. annæ*, from Sumatra. I have already (*supra* p. 241) given my reasons for following Yabe who includes this species in his subgenus *Neoschwagerina*.

N. annæ has been described in detail by Volz, who gives good figures of characteristic sections and I have little to add. One of the chief points not hitherto referred to is the extreme tenuity of the shell, which ranges in my specimens from 4 μ to 15 μ in thickness. It is so thin that it is very difficult to recognise any structure in it, but in a few cases I have been able to ascertain beyond a doubt that it was perforated, although for the greater part it appears to have been imperforate. The perforate material does not usually extend appreciably below the level of the inner side of the shell wall, the entire septum being always imperforate. The total amount of perforate material is thus insignificant in comparison with that of the imperforate.

The number of auxiliary septa, as stated by Volz, is variable. In my specimens it ranges from one to five in a meridional, and one to three in an equatorial, direction. Where there are three auxiliary equatorial septa, the middle one is usually larger than those on either side. The meridional septa always appear to be more numerous than the equatorial, the number ranging from one in the innermost whorls to as many as five in the outermost. I have not noticed more than three auxiliary equatorial septa and this only in the outer whorls; one and two are commonest but the number increases with the growth of the individual.

A characteristic feature of this species is the shape of the septa, which are very narrow at their points of attachment to the wall but rapidly broaden out below; the sections of the short auxiliary septa look like a row of grapes each hanging by a thin stalk from the roof of the chamber.

Both Volz and Yabe speak of the large size of the central chamber. Among my Afghan specimens there are forms both with large and small chambers, the largest being 450 μ (Pl. 22, figs. 10 and 11) and the smallest 150 μ (Pl. 22, fig. 8). These may perhaps represent the megalospheric and microspheric forms respectively, but as there are intermediate values also, 260 μ and 300μ among my specimens, they may all be megalospheric.

DIMORPHISM IN THE FUSULINIDÆ.

This phenomenon has been so generally recognised in Tertiary and recent foraminifera that it is surprising that it should not yet have been described in the case of the *Fusulinidæ*. Schellwien had evidently noticed it, since, in his posthumous monograph on *Fusulina* now in course of publication,[1] some of the figured specimens are described as megalospheric and others as microspheric, but no discussion of the subject has yet appeared. Dimorphism has now been established for *Neoschwagerina craticulifera* Schw. and it may also occur in *N. annæ* Volz, and *Fusulina elongata* Shum. It is interesting to note that although in the case of the *Fusulinæ* proper the megalospheric form is apparently the commoner, its occurrence has been recorded only once in the case of *Neoschwagerina craticulifera* Schw. and not at all, so far as I am aware, in the subgenus *Schwagerina*.

SUMMARY.

1. The Fusulina limestone of Afghanistan contains *F. uralica* Krotow and *F. elongata* Shumard in profusion. It also contains *Schwagerina princeps* Ehrenberg, *Sch. lepida* Schw., *Neoschwagerina craticulifera* Schw., and a new species *N. primigena* mihi.

2. A study of the shell-structure proves that the material of which the shells of the *Fusulinidæ* was composed was not vitreous but cryptocrystalline and was identical with that of the *Porcellanea.* At the same time it was also perforate.

3. The so-called "basal skeleton (Basalskelet)" of *Schwagerina* is merely an exogenous growth of imperforate material extending from the base of the septa across the floor of the chambers. It

[1] *Palæontographica*, Band 55, 145 (1908).

takes various forms, sometimes rising into definitely oriented ridges (*Sch. lepida* Schwager); but these characters are not of subgeneric importance. The form *Sch. verbeeki* Geinitz is not, in my opinion, a valid species, since its characteristic section can be obtained by cutting a specimen of *Sch. princeps* Ehr. in certain definite directions.

4. Von Moeller's genus is divided into two subgenera, *viz.*, *Schwagerina* (*sensu stricto*), which is characterised by the presence of only one set of septa ("primary meridional") and *Neoschwagerina*, which has at least two sets of septa, one being the "primary meridional" and the other the "primary equatorial" which are at right angles to the meridional. There may also be auxiliary meridional and auxiliary equatorial septa, all of which constitute the "Dachskelet" of German authors.

6. A new species of *Neoschwagerina*, *N. primigena*, is described; it is intermediate between *Schwagerina lepida* Schwager and *Neoschwagerina craticulifera* Sch.

7. In the more complicated forms of *Neoschwagerina* (*N. annæ* Volz) the proportion of imperforate material is very large as compared with that of perforate and it is suggested that *Alveolina* may possibly be the final stage in the progressive suppression of perforations in the *Fusulinidæ*.

8. The fauna of the Afghan Fusulina limestone is a peculiarly interesting one. In the first place it contains the very remarkable species *F. elongata* Shumard, which, so far as I am aware, has hitherto been recorded only from the southern end of the Guadalupe Mountains in Texas. On the other hand, it contains also *Fusulina uralica* Krotow, a common species in the Tscherdyn and Ssolikamsk area of the Urals in European Russia, whilst associated with these forms, characteristic of such widely separated localities, are others—*Neoschwagerina annæ* Volz and *N. craticulifera* Schwager—typical of the intervening areas, Sumatra, China and Japan. All these again are found in close association with beds containing typical Carboniferous brachiopods, *Productus punctatus* Martin and *Reticularia lineata* Mart.; *Productus punctatus* is extremely common and quite dominates the small fauna collected from the brachiopod-bearing horizon in the Fusulina limestone of Bamian. This fauna has not yet been completely worked out and it would be useless to attempt to discuss its relationship to Carboniferous faunas in other parts of the world, but the general characters of the brachiopods

as well as the frequent occurrence of *Fusulina uralica* Krotow and *Schwagerina princeps* Ehrenberg, seem to point to a correlation of the Afghan Fusulina limestone with the Upper Carboniferous (Cora and Schwagerina horizons) of the Urals; at the same time there are affinities with the Guadalupian fauna of Texas and with the Upper Carboniferous of Sumatra, Java, China and Japan.[1]

EXPLANATION OF PLATES.

PLATE 17.

Fig. 1.—Transverse section of *Fusulina,* showing the structure of the shell: the dark lines are shell and the light intervening spaces perforations . . . . × 50[2]

Fig. 2.—Transverse section of *Fusulina,* showing the structure of the shell: the dark lines are shell and the light intervening spaces perforations. Both this figure and fig. 1 show the apparent branching of the shell in the outer layer . . × 70

Figs. 3, 4.—Tangential section of shell of *F. elongata* Shum., showing perforations. The shell-substance is dark and the perforations appear as white dots . . . . . . × 40

Fig. 5.—The same as lower part of fig. 4 . . . . . . × 90

Fig. 6.—Approximately tangential section of shell of *F. uralica* Krotow, showing the perforate shell-wall (*a*) and imperforate septa (*b*). The dark spots represent the perforations. From left to right the shell-wall merges into, and is perfectly continuous with, the septum. On the right-hand side of each septum is a dark line of division (*c*) along which the wall of a new chamber abuts against the septum of the preceding chamber. The figure also shows oral apertures (↑) in the septal face . . . . . . × 33

Fig. 7.—Part of the same enlarged to show that the perforations are not in reality filled with dark material, but contain transparent calcite (?), surrounded by a rim of dark ferruginous material (p. 234) . . . . × 60

PLATE 18.

Fig. 1.—Transverse section of *Schwagerina princeps* Ehr. A section taken at right angles to the plane of the paper and along the line *a* . . . . *a* would cut few if any septa, as in fig. 2, whereas a similar section along *b* . . . . *b* would cut a septum in almost every whorl, as in fig. 3 . . . . . . × 50

[1] In his paper "On a Fusulina limestone with *Helicoprion* in Japan" (*Journ. Geol. Soc. Toyko,* Vol. X, No. 113, 1903) Yabe referred part of the Fusulina limestone of Japan to the Permian system, but in his more recent paper (*Journ. Coll. Sci. Imp. Univ. Tokyo,* Vol. XXI, Art. 5, 1906-07), he seems doubtful as to the exact position of the limestone in the Upper Palæozoic sequence.

[2] i. e., 50 *diameters.*

Fig. 2.—Meridional section of *Schwagerina princeps* Ehr., with only minute traces of a "basal skeleton" in the outermost whorls . . . . × 12

Fig. 3.—Similar section of the same species, but cut so as to show "basal skeleton" in most of the whorls. This corresponds to *Sch. verbeeki* Geinitz . . . . . . × 12

Fig. 4.—Section of *Sch. princeps*, taken at some distance from the central chamber, but approximately parallel to the axis. In the upper right-hand segment are portions of two septa in the plane of the section: on either side of these curtains can be seen the exogenous outgrowths from the bases of the septa (basal skeleton). In the lower half of the figure the section includes chiefly the central parts of the septa . × 12

Fig. 5.—Transverse section of *Sch. princeps* cut at some distance from the central chamber and showing exogenous thickening of the bases of the septa . . . . . × 12

Fig. 6.—Somewhat oblique section of *Sch. princeps*. The upper part of the figure shows a parallel section of the lower two-thirds of a septum . . . . × 12

Fig. 7.—Shell of *Fusulina* showing the dark imperforate septa running between the perforate walls (uppermost part of the figure) . × 17

PLATE 19.

Fusulina uralica Krotow.

Figs. 1—6.—Specimens of various sizes: all natural size: fig. 4 represents a typical specimen.

Fig. 7.—Longitudinal (meridional) section of a large specimen . . × 4

Fig. 8.—The same . . . . × 10

Fig. 9.—Similar section of another specimen . . . . . . × 10

Figs. 10, 11 *and* 12.—Transverse (equatorial) sections of typical specimens of various sizes . . . . × 10

Fig. 8 illustrates a specimen with a large central chamber.

PLATE 20.

Fusulina elongata Shumard.

Fig. 1.—Central part of a longitudinal (meridional) section of a medium-sized specimen similar to those illustrated in fig. 10 . × 12

Figs. 2—5.—Transverse (equatorial) sections of similar specimens; fig. 4 is cut at a little distance from the central chamber . × 12

Figs. 6, 7.—Traverse (equatorial) sections of small specimens similar to those illustrated in fig. 11 . . . . . × 12

Figs. 8, 9.—Longitudinal sections of similar specimens, showing the small number of whorls . . . . × 12

Fig. 10.—Limestone with medium-sized specimens: natural size.

Fig. 11.—Limestone with small specimens: natural size.

Figs. 1 to 11 probably represent the megalospheric form.

Fig. 12.—Very large specimen (? microspheric form): natural size.

PLATE 21.

Figs. 1 and 3.—Typical longitudinal (meridional) sections of *Neoschwagerina craticulifera* Schwager. Fig. 1 × 15, fig. 3 × 12.

Figs. 2 and 7.—Typical transverse (equatorial) sections of the same species. Fig. 2 × 15, fig. 7 × 11.

Fig. 4.—Characteristic longitudinal section of *N. craticulifera*, cut at some little distance from the central chamber. The dark imperforate parts of the septa (shown by arrows) are seen between the paler perforate shell-wall. The section corresponds to one cut at right angles to the plane of the paper and along the line *a*......*a*, so as just to touch the floor of the chamber. The dark grating in the centre is formed by the traces of the imperforate lower parts of the meridional and equatorial septa and constitutes the so-called "basal skeleton." The cloudy material between the bars of the grating is the outer part of the perforate shell-wall cut horizontally: the photograph is on too small a scale to show the perforations, which, however, can be clearly seen under the microscope . . . . × 20

Fig. 5.—Transverse section of part of the shell of *N. craticulifera*. showing primary meridional septa (*p*) and auxiliary meridional septa (*a*) both cut at right angles. *e* represents part of a primary equatorial septum to which the plane of the section is parallel. Yabe's "median lamella" is well seen in each of the primary meridional septa . . × 46

Fig. 6.—Part of a similar section enlarged to show the perforations: the dark lines are shell and the intervening lighter streaks represent the perforations . . . . × 90

Both figs. 5 and 6 show the dark outer line (of supposed exogenous material) which is due to branching of the walls of the perforations, as well as the dark imperforate material forming the base of the septa and spreading over the floor to form the "basal skeleton."

Fig. 8.—Transverse section of *Alveolina* (*Flosculina*) *pasticillata* Schw from Sind, showing sections of the longitudinal galleries. Similar galleries are seen in *N. craticulifera* in figs. 7 (↓) and 2 (in the lower left-hand segment) . . . . × 12

PLATE 22.

Figs. 1—4.—Longitudinal section of ***Neoschwagerina primigena***, nov. sp. × 17

Fig. 5.—Transverse section of the same . . . . × 20

Figs. 6 ***and*** 7.—Transverse section of the same . . . . . . × 17

Figs. 8, 9 ***and*** 10.—Longitudinal sections of ***Neoschwagerina annæ*** Volz, showing the varying size of the central chamber . × 10

Fig. 11.—Specimen shown in fig. 10 enlarged. The upper left-hand corner of the figure illustrates the peculiar grape-like section of the septa . . . . × 20

Fig. 12.—Transverse section (not through the central chamber) of ***N. annæ***, showing the large number (4 in the outer whorls) of auxiliary meridional septa. The extreme tenuity of the shell is also noticeable: it appears merely as a dark line from which the septa depend. Both this figure and the next show the unusual thickness of the primary meridional septa, a feature very characteristic of the species . × 23

Fig. 13.—Transverse (equatorial) section through the central chamber of another specimen of ***N. annæ***. . . . . . × 20

Fig. 14.—Part of a very characteristic section of Neoschwagerina limestone, containing ***N. annæ***: it shows a transverse section, a longitudinal (meridional) section through the central chamber, and an approximately longitudinal section slightly oblique to the axis and at some distance from the central chamber . . . . × 12

MISCELLANEOUS NOTES.

Oil at Jaba, Mianwali District, Punjab.

A mile and a half south of Jaba (Lat. 32° 52′, Long. 71° 43′) is a small gorge called *Chhota Khatta* and two-thirds of a mile further is another such called *Bara Khatta.* The brooks from these two unite to form the stream passing by Jaba. On the right bank of the former and on the left one of the latter, *i. e.*, on the two flanks of the eminence between the two gorges, less than ten feet above the stream beds and in the upper 250 feet of the upper or compact nummulitic limestone are to be found the oil-springs, seven in the *Chhota* and three in the *Bara Khatta.* One of the latter is altogether insignificant and the other two are only slightly less so.

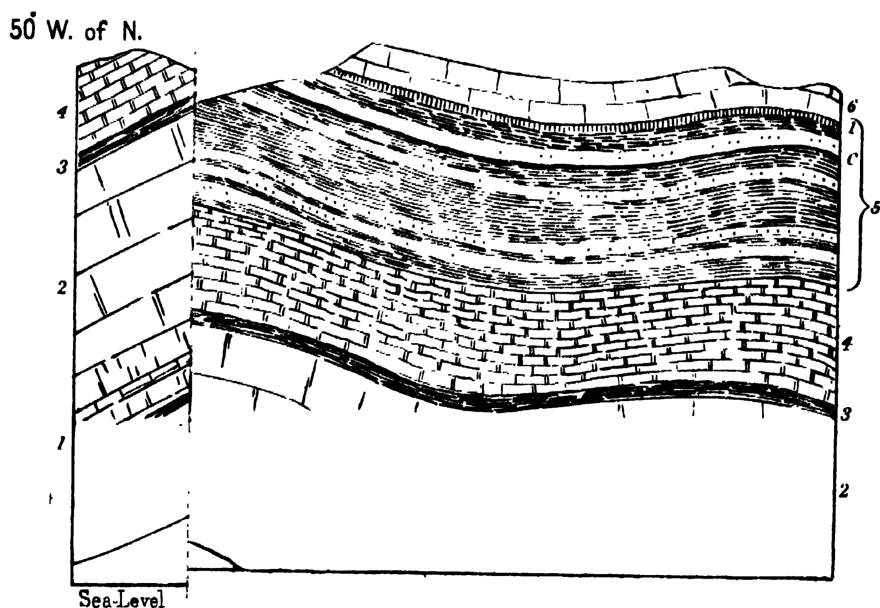
At all the ten the oil issues drop by drop from little crevices in the rock and is allowed to collect in sumps and from these to overflow into the streams where it is stopped by miniature dams. It is thence ladled out from time to time and stored in a 150 gallon tank, the monthly output being 50 gallons of a thick greenish-black sulphurous-smelling oil.

Just a little west of the springs in the *Chhota Khatta* is a small subsidiary synclinal, followed on the east by a nearly flat anticlinal and this, in its turn, by a larger synclinal, about 450 feet from the smaller one and pitching to the north-east by north. Even this is nearly flat and narrow as the Siwalik rocks are to be seen dipping away close by and the ground here is very much disturbed.

A syndicate who bored here for oil met at a depth of 117 feet with only a powerful spring of fresh water which rose to a height of five feet above the ground and drained dry both the "*Khattas*," and great hopes cannot be entertained for a copious flow of oil.

[N. D. DARU.]

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ble junction of Laki and Khirthar.

T WEST OF JOHAN.



E. W. Vredenburg photo. *G. S. I. Calcutta.*

HIPPURITES GOSAVIENSIS, Douvillé.

1, *a*, *b*, *c*.—Anterior, posterior, and upper aspects of an almost complete lower valve.

2. Polished surface of another lower valve.

Both specimens from Koh-i-Narahu.

(Natural size.)



E. W. Vredenburg photo. *G. S. I. Calcutta.*

PIRONÆA PERSICA, nov. sp.

1. Complete specimen with upper valve preserved.
2. Fragment of a lower valve.— 3. Polished section of another specimen.

All three specimens from Koh-i-Narahu.

(Natural size.)



E. W. Vredenburg photo. *G. S. I. Calcutta.*

1 *a.*—Cast of a Nerinea. 1 *b.* -Section of the same specimen.
2.--Gen. indet., spec. indet.
Both specimens from Koh-i-Maku.
(Natural size.)

Records Vol. XXXVIII, Pl. 17.



1 (× 50)



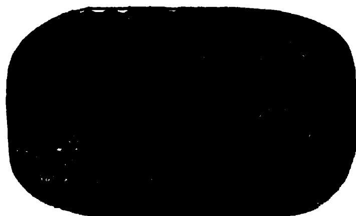
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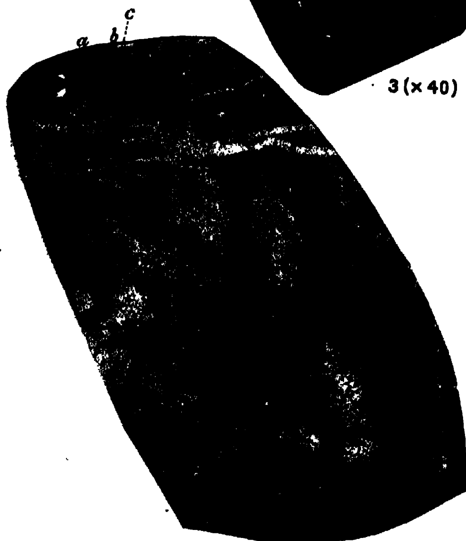
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3 (× 40)



4 (× 40)





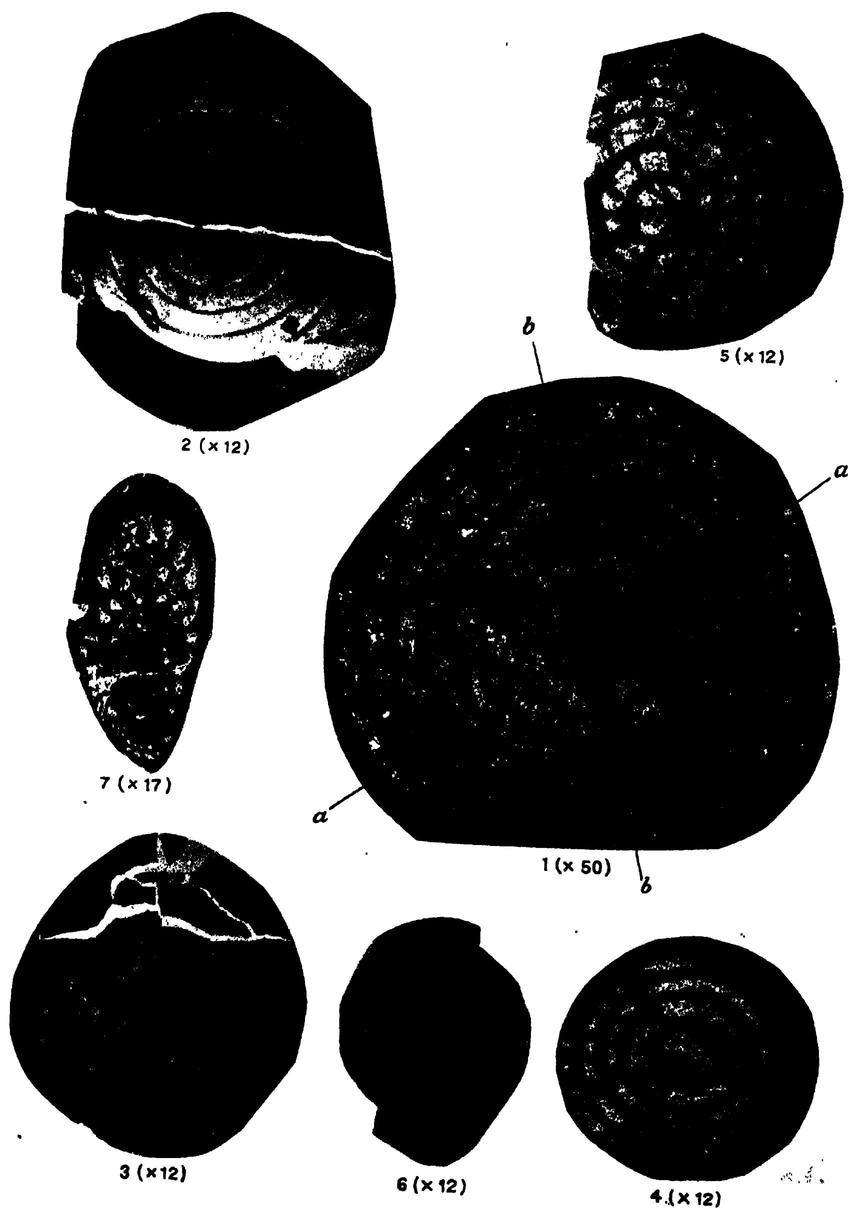
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6 (× 33)

H. H. Hayden photo.

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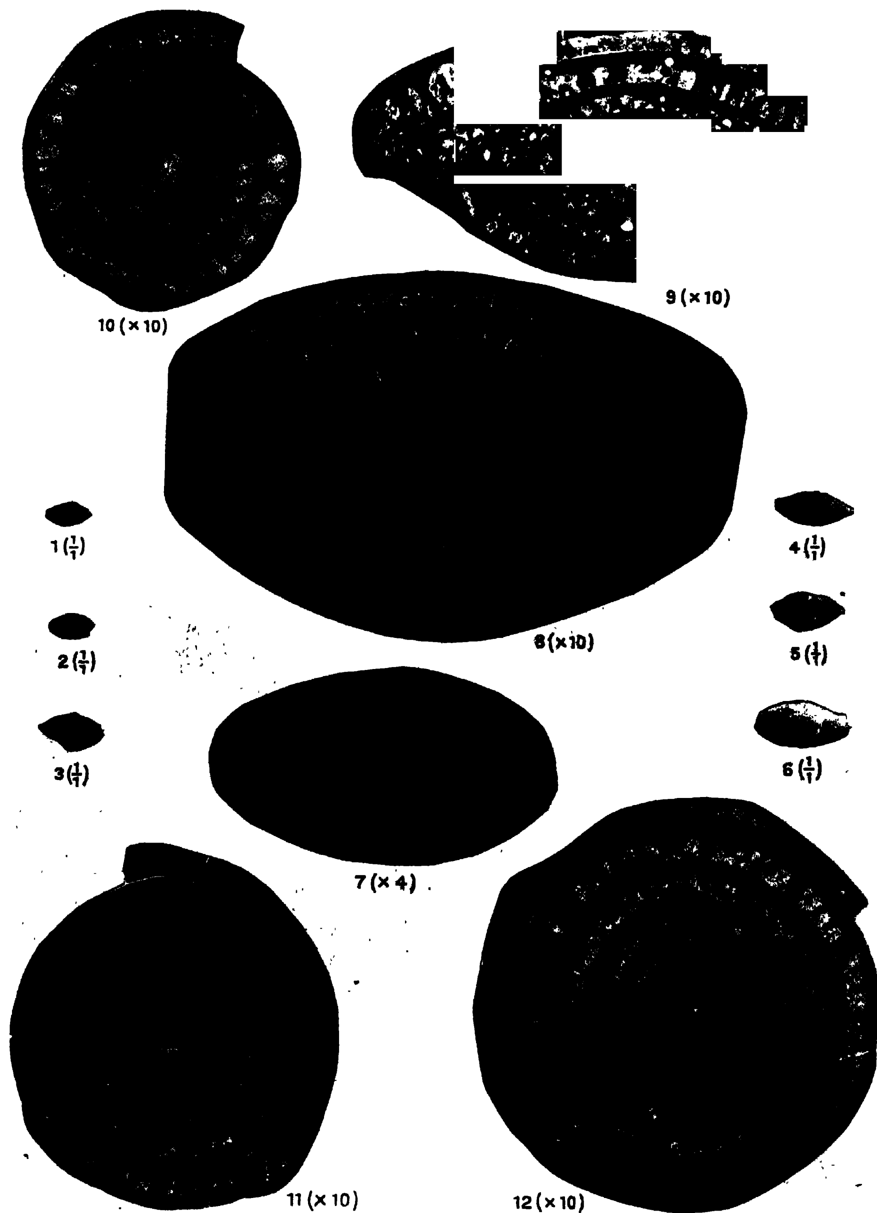
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H. H. Hayden photo.

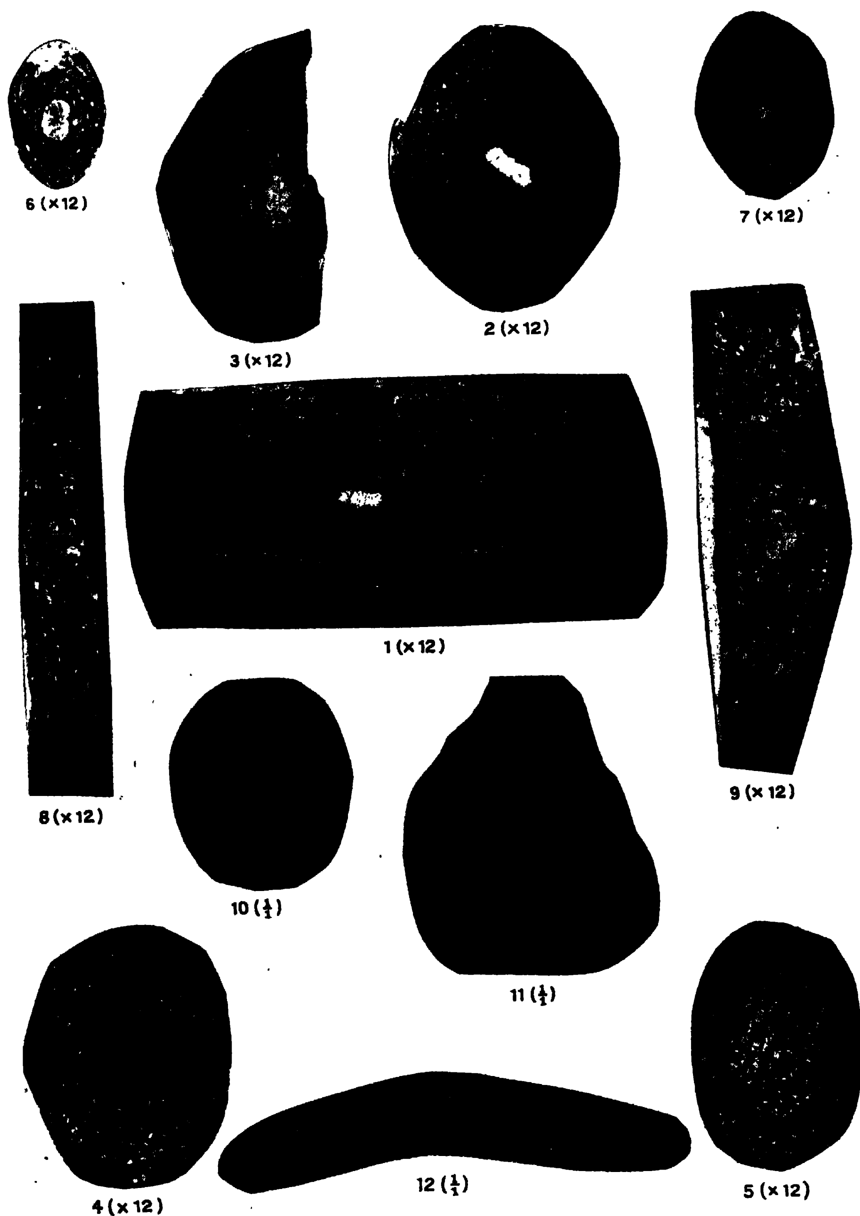
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G. S. I. Calcutta.



H. H. Hayden photo. *G. S. I. Calcutta.*

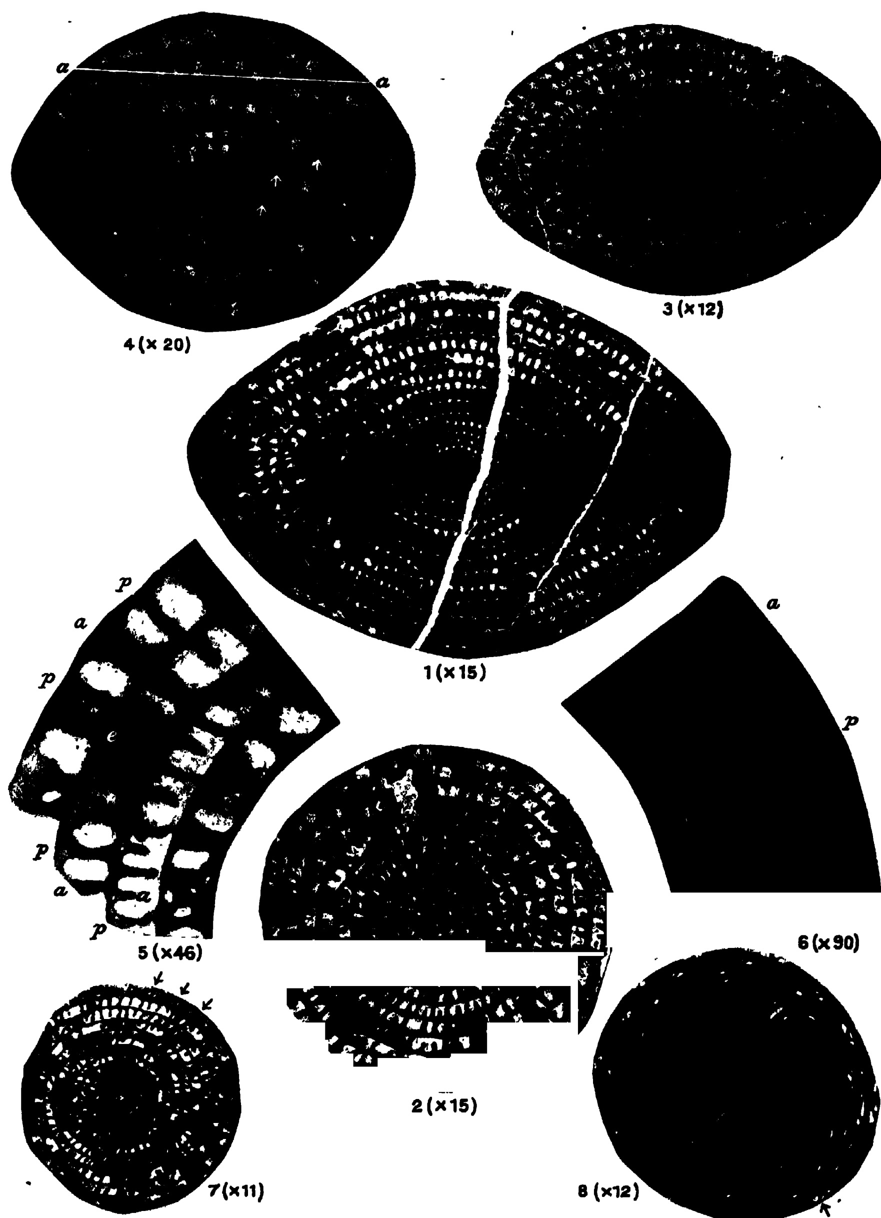
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G. S. I. Calcutta.

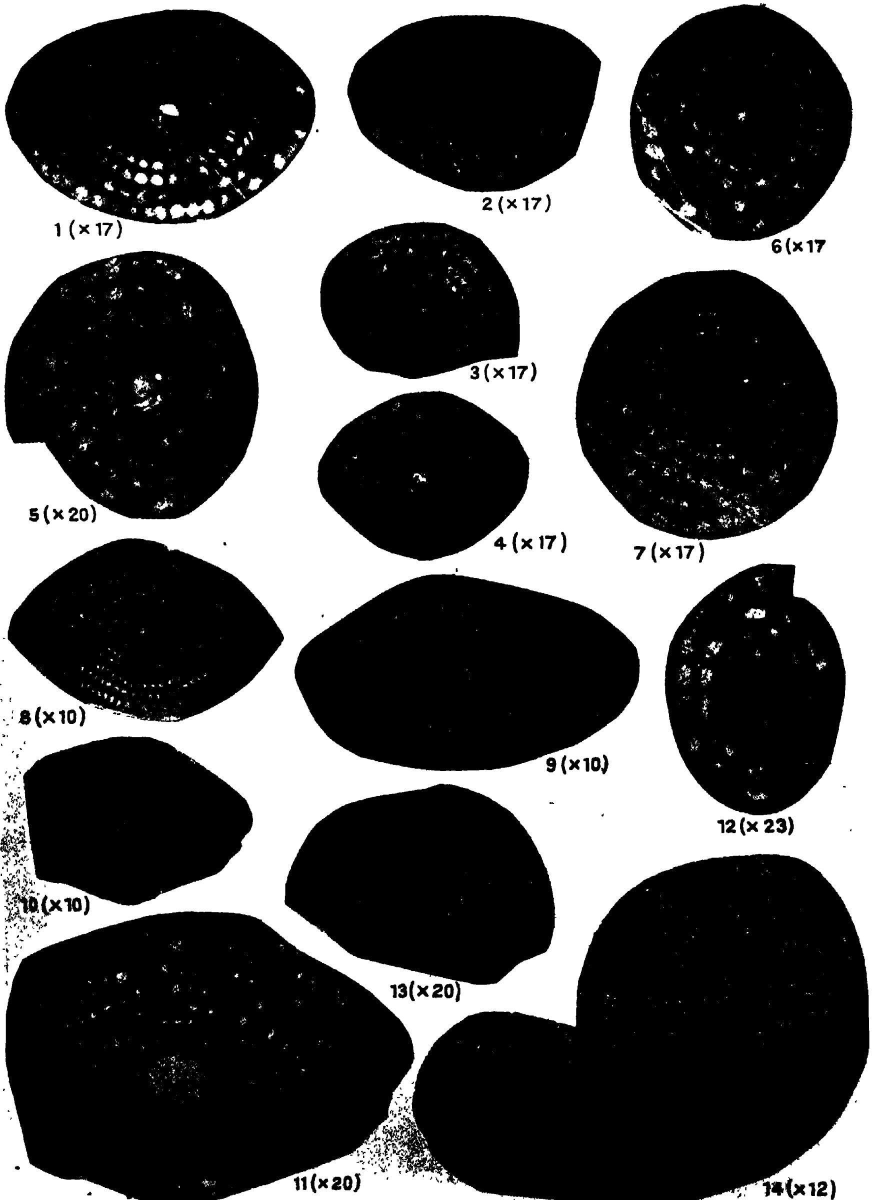
AFGHAN FUSULINIDÆ



H. H. Hayden photo.

G. S. I. Calcutta.

AFGHAN FUSULINIDÆ.



H. H. Hayden photo

G. S. I. Calcutta.

AFGHAN FUSULINIDÆ

Part 2 (out of print).—Rocks of the Lower Godavari. 'Atgarh Sandstones' near Cuttack. Fossil floras in India. New or rare mammals from the Siwaliks. Arvali series in North-eastern Rajputana. Borings for coal in India. Geology of India.

Part 3 (out of print).—Tertiary zone and underlying rocks in North-west Punjab. Fossil floras in India. Erratics in Potwar. Coal explorations in Darjiling district. Limestones in neighbourhood of Barakar. Forms of blowing-machine used by smiths of Upper Assam. Analyses of Raniganj coals.

Part 4.—Geology of Mahanadi basin and its vicinity. Diamonds, gold, and lead ores of Sambalpur district. 'Eryon Comp. Barrovensis,' McCoy, from Sripermatur group near Madras. Fossil floras in India. The Blaini group and 'Central Gneiss' in Simla Himalayas. Tertiaries of North-West Punjab. Genera Chœromeryx and Rhagatherium.

VOL. XI, 1878.

Part 1.—Annual report for 1877. Geology of Upper Godavari basin, between river Wardha and Godavari, near Sironcha. Geology of Kashmir, Kishtwar, and Pangi. Siwalik mammals. Palæontological relations of Gondwana system. 'Erratics in Punjab.'

Part 2.—Geology of Sind (second notice). Origin of Kumaun lakes. Trip over Milam Pass, Kumaun. Mud volcanoes of Ramri and Cheduba. Mineral resources of Ramri, Cheduba and adjacent islands.

Part 3.—Gold industry in Wynaad. Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

Part 4.—Geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

VOL. XII, 1879.

Part 1.—Annual report for 187[illegible] Ge[illegible]ogy of Kashmir (third notice). Siwalik mammalia. Siwalik birds. Tour thr[illegible]angrang and Spiti. Mud eruption in Ramri Island (Arakan). Braunite, wit[illegible]donite, from Nagpur, Central Provinces. Palæontological notes from Satpura [illegible]sin. Coal importations into India.

Part 2.—Mohpani coal[illegible]ite with Psilomelane at Gosalpur, Jabalpur district. Geological[illegible]naissance from [illegible]dus at Kushalgarh to Kurram at Thal on Afghan frontier. [illegible]ology of Upper Punjab.

Part 3.—G[illegible]gical features of northern Madura, Pudukota State, and southern parts of Tanjo[illegible] and Trichinopoly districts included within limits of sheet 80 of Indian Atlas. Cret[illegible]eous fossils from Trichinopoly district, collected in 1877-78. Sphenophyllum and other Equisetaceæ with reference to Indian form Trizygia Speciosa, Royle (Sphenophyllum Trizygia, Ung.). Mysorin and Atacamite from Nellore district. Corundum from Khasi Hills. Joga neighbourhood and old mines on Nerbudda.

Part 4.—'Attock Slates' and their probable geological position. Marginal bone of undescribed tortoise, from Upper Siwaliks, near Nila, in Potwar, Punjab. Geology of North Arcot district. Road section from Murree to Abbottabad.

VOL. XIII, 1880.

Part 1.—Annual report for 1879. Geology of Upper Godavari basin in neighbourhood of Sironcha. Geology of Ladak and neighbouring districts. Teeth of fossil fishes from Ramri Island and Punjab. Fossil genera Nöggerathia, Stbg., Nöggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Fossil plants from Kattywar, Shekh Budin, and Sirgujah. Volanic foci of eruption in Konkan.

Part 2.—Geological notes. Palæontological notes on lower trias of Himalayas. Artesian wells at Pondicherry, and possibility of finding sources of water-supply at Madras.

Part 3.—Kumaun lakes. Celt of palæolithic type in Punjab. Palæontological notes from Karharbari and South Rewa coal-fields. Correlation of Gondwana flora with other floras. Artesian wells at Pondicherry. Salt in Rajputana. Gas and mud eruptions on Arakan coast on 12th March 1879 and in June 1843.

Part 4.—Pleistocene deposits of Northern Punjab, and evidence they afford of extreme climate during portion of that period. Useful minerals of Arvali region. Correlation of Gondwana flora with that of Australia coal-bearing system. Reh or alkali soils and saline well waters. Reh soils of Upper India. Naini Tal landslip, 18th September 1880.

VOL. XIV, 1881.

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts. Siwalik carnivora. Siwalik group of Sub-Himalayan region. South Rewah Gondwana basin. Ferruginous beds associated with basaltic rocks of north-eastern Ulster, in relation to Indian laterite. Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on lower trias of Himalayas.' Mammalian fossils from Perim Island.

Part 2.—Nahan-Siwalik unconformity in North-Western Himalaya. Gondwana vertebrates. Ossiferous beds of Hundes in Tibet. Mining records and mining record office of Great Britain; and Coal and Metalliferous Mines Act of 1872 (England). Cobaltite and danaite from Khetri mines, Rajputana; with remarks on Jaipurite (Syepoorite). Zinc-ore (Smithsonite and Blende) with barytes in Karnul district, Madras. Mud eruption in island of Cheduba.

Part 3.—Artesian borings in India. Oligoclase granite at Wangtu on Sutlej, North-West Himalayas. Fish-palate from Siwaliks. Palæontological notes from Hazaribagh and Lohardagga districts. Fossil carnivora from Siwalik hills.

Part 4.—Unification of geological nomenclature and cartography. Geology of Arvali region, central and eastern. Native antimony obtained at Pulo Obin, near Singapore. Turgite from Juggiapett, Kistnah district, and zinc carbonate from Karnul, Madras. Section from Dalhousie to Pangi, *viâ* Sach Pass. South Rewah Gondwana basin. Submerged forest on Bombay Island.

Vol. XV, 1882.

Part 1 (out of print).—Annual report for 1881. Geology of North-West Kashmir and Khagan. Gondwana labyrinthodonts. Siwalik and Jamna mammals. Geology of Dalhousie, North-West Himalaya. Palm leaves from (tertiary) Murree and Kasauli beds in India. Iridosmine from Noa-Dihing river, Upper Assam, and Platinum from Chutia Nagpur. On (1) copper mine near Yongri hill, Darjiling district; (2) arsenical pyrites in same neighbourhood; (3) koalin at Darjiling. Analyses of coal and fire-clay from Makum coal-field, Upper Assam. Experiments on coal of Pind Dadun Khan. Salt-range, with reference to production of gas, mad April 29th, 1881. Proceedings of International Congress of Bologna.

Part 2 (out of print).—Geology of Travancore Sta[illegible] rkilli beds and reported associated deposits at Quilon, in Travancore. Siwalik [illegible] Narbada fossils. Coal-bearing rocks of Upper Rer and Mand rivers in Western [illegible] Nagpur. Pench river coal-field in Chhindwara district, Central Provinces. [illegible] for coal at Engsein, British Burma. Sapphires in North-Western Himala[illegible] eruption [illegible] mud volcanoes in Cheduba.

Part 3.—Coal of Mach (Much) in Bolan Pass, and of Sharigh on Harn[illegible]ute between Sibi and Quetta. Crystals of stilbite from Western Ghats, Bombay. T[illegible] of Darang and Mandi in North-Western Himalayas. Connexion between Hazara a[illegible] Kashmir series. Umaria coal-field (South Rewah Gondwana basin). Daranggiri coal-field, Garo Hills, Assam. Coal in Myanoung division, Henzada district.

Part 4 (out of print).—Gold-fields of Mysore. Borings for coal at Beddadanol, Godavari district, in 1874. Supposed occurrence of coal on Kistna.

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Part 1.—Annual report for 1882. Richthofenia, Kays (Anomia Lawrenciana, Koninck). Geology of South Travancore. Geology of Chamba. Basalts of Bombay.

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